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DETERIORATION OF AMERICAN OYSTER-BEDS.

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II.

AN oyster-bed, in its natural and undisturbed state, consists of a long, narrow ridge of shells and oysters, lying generally in brackish water, on and surrounded by sticky bottoms, a mixture similar to clay and mud being the most favorable.

The form and area of the bed are variable, but, naturally, the length is greater than the breadth, and the greatest dimension is usually in the direction of the current. The bed itself is made up of masses of shells and oysters, covering areas of different sizes, and separated from each other by mud or sand-sloughs, though frequently it is unbroken, and the animals spread evenly and continuously over the entire area. This separation and detachment of the groups of animals are much more noticeable upon a bed which has been much worked. Upon an unworked bed, or one in its natural state, the oysters grow in clusters, and are firmly cemented to the bottom. Upon a bed which has been frequently dredged, the animals are single, and have no hold upon the bottom.

The fauna of the bed varies with the locality; in the Chesapeake it is somewhat sparse.

The bottom is usually of clay or mud, and of sufficient consistency to support the oysters; certain varieties of bottom are more favorable than others, but, except within wide limits, the character of the bottom does not appear to be of great importance, so long as it is sufficiently firm to prevent the animal from sinking into it and thus smothering.

The oyster thrives best in slightly brackish water, and the finest varieties are usually found in water of a lower specific gravity than

that of the sea, but the density is not important, except within wide limits, though the specific gravity should not fall below 1·01 at 60° Fahr., distilled water being represented by 1·00. The main necessity is that the water should contain a sufficient amount of lime to furnish the animal with the principal constituent of its shell.

The mature marketable oyster is so well known that it is unnecessary to describe it; but the following will assist the reader, who is not acquainted with the anatomy of the animal, to a correct appreciation of the facts stated and terms used in subsequent pages:

That part of the oyster usually known as the heart is a muscle, called the abductor muscle; its office is to keep the valves (or shell) closed, and prevent the ingress of deleterious matter.

The two valves are hinged at the round, blunt end of the shell, and between this hinge and the abductor muscle lies the body of the oyster or *visceral mass*, which is made up of the light-colored reproductive organs and the dark-colored digestive ones, packed together in one continuous mass. The mouth of the oyster is that part nearest the hinge, and what is usually called the "beard" of the animal is known as the "gills."

The oyster lies on its side in the shell, and the minute animal and vegetable organisms contained in the water, and which form the food of the animal, are passed along between the gills to the mouth by the action of myriads of small vibrating hairs, called *cilia*. These cilia cover the surface of the gills, and, by a rapid and simultaneous motion in one direction and a slow one in the opposite, cause a strong current to set into the lips of the valves, bringing in not only what is suitable for food, but many other minute organisms and particles which thus come in contact with the gills and what they may hold.

The European oyster (*Ostrea edulis*) and the American oyster (*Ostrea Virginiana*) are varieties of the same family, and, though differing in several particulars, are not so dissimilar but that the conditions favorable to the growth and life of one may be considered as equally so for the other. With each variety the formation of the generative matter is gradual, and the spawning-season of both is during the early summer months, its advent depending probably upon the temperature, the higher temperature hastening and the lower retarding that event. No particular temperature can be assigned, as it depends greatly upon the locality, but departures from the normal temperature of the spring and summer months will have the effect described. In the same way an increased or diminished density of the water, whether due to change of temperature or to the addition of water of greater or less specific gravity than that usually surrounding the animals, has probably a similar accelerating or reverse effect upon the spawning, though as yet we can not speak with certainty upon this point.

Generally, both in Europe and America, the spawning-season may be said to be from June 1st until August 15th, though variations of

the temperature and density of the surrounding waters may expand or contract that period considerably.

All authorities upon the early stages of the European variety concur in the statement that the young oyster or "spat" is formed by the fertilization of the eggs of the female while within the shell of that animal, and that the "spat" is held between the gills, and thus protected by the parent until the shell has formed. Many authorities are also of the opinion that the parents are hermaphrodites, and it is here that the first difference between the European and American varieties is noticed. Professor W. K. Brooks, in his recent paper upon the embryology of the American oyster, states that, though he has during the past two years examined a very large number of oysters, he has never found any evidence of a union of the two sexes in the same animal; and my own more limited observations have likewise failed to discover any such indication.

The second and most material difference is in the manner of impregnating the eggs of the female. According to the best authorities the fertilization of the eggs of the European variety is accomplished by the passage of the male fluid into the water, and thence between the valves and gills of the female, where the eggs, having been expelled from the ovaries, are lying ready for fertilization. The young resulting from the union of the ova and spermatozoa are held and protected within the gills of the female until the shells have formed and until they are quite well advanced in development, having at the time of their expulsion locomotive powers of their own, which enable them to swim about and seek an appropriate place for attachment.

The American variety, according to the observations of Dr. Brooks, differs in this, that the young oyster is not found within the gills of either parent, nor does the fertilization take place within the shell, but the contents of the generative organs of both sexes are expelled into the water, there to stand the chance of coming into contact. My own observations support this theory, inasmuch as relates to the presence of young within the gills, I having examined those parts of a large number of oysters very carefully, and with an utter failure to discover an embryo oyster, even during the height of the spawning.*

It is evident that a large measure of protection is afforded the young of the European variety by the inclosing shells of the parent, and that this protection is given during the most precarious stages of their existence, while the ova and spermatozoa of the American oyster are not only left to a happy chance for their successful union, but the

* At least one variety of the European oyster is reproduced in a manner similar to our own. During the summer of 1880 I successfully impregnated the eggs of several female oysters, taken from the Bay of Cadiz, Spain. The embryo were maintained alive for eight days, and their development was entirely similar to that of the American variety.

resulting young are exposed, unprotected, to all the vicissitudes of climate and to the ravages of all enemies.

After the formation of the shell, and the development of the locomotive powers, the young of both varieties begin their search for a permanent resting-place or point of attachment. The swimming period is of short duration, and the powers of locomotion are not very great; consequently, such points of attachment must soon be obtained, or the young oyster perishes. Any moderately rough, hard substance, provided that the surface is clean, is suitable for attachment, and such objects, when exposed for the purpose of attracting the young brood, are called "cultch." Pieces of wood, boughs of trees, planks, stones, old shells, tiles, and fagots, have all been successfully used. It is only necessary that the surface should be hard and clean, and, if dark-colored, so much the better. Upon finding the "cultch," the "spat" attaches itself firmly, and is thenceforward, so far as its own power is concerned, located for ever; all future movement and change of position are due to causes, natural or otherwise, over which it has no control.

The development now is one of ordinary growth, the animal having passed through its embryonic life; its organs are formed and are in active operation; it is but immature. The increase in size and the development of the different parts, or, in other words, the growth, are much more rapid with the American variety than with the European. Though we have no record extending over any length of time, and none of different localities, yet the observations during the summer of 1879 in Chesapeake Bay show that in the first three months of existence the oyster in that locality increases in size from a hardly visible speck to an average length of one and a quarter inch, and a few were over two inches long. The lower and attached side grows the most rapidly, and during this first period the growth is mainly in length; there is, of course, a development in all directions, but the greatest is toward the lips of the shell. After the first year, the increase in size is not so rapid, and oysters of two or three years of age are about two inches broad and three inches long, though those dimensions will vary considerably in different localities on account of the different conditions to which the animals are subjected; in three years at the most the American oyster is considered mature, and will present all the characteristics of those found in the markets. With the European variety the growth is much slower, and at maturity they are very much smaller than the American oyster: but this difference is immaterial to the question under consideration, and all that is necessary to notice is the consequence of the different methods of propagation.

With all animals Nature strives to provide against the destruction of the young after birth by insuring a sufficient number to allow for all ravages; and the greater the dangers to which the immature of any species is exposed, the larger will be the number provided to meet

those dangers. Hence, as the embryo European oyster receives some protection and the American none, it is inferred that the number of American embryos in any community will be subjected to greater danger, and consequently it is probable that a larger number of eggs and spermatozoa are provided, that the production may not be less. If this is not the case, then the reproduction upon the European beds is much greater than upon our own. Let us see if the investigations, conducted both in this country and abroad, support this conclusion.

Professor Möbius, in his work upon the oyster and oyster-culture, estimates the number of eggs spawned by the European variety as about 1,800,000, and his estimate is supported by Eyton, in his "History of the Oyster and Oyster-Fisheries."

Professor Brooks estimates the possible number of eggs spawned by the American variety to be as large as sixty millions, and the average number to be over nine millions, or the American oyster spawns about nine times as many eggs as the European. The number of male cells is so great that, even if it were possible, it would be unnecessary to estimate them; but, from the comparison of the numbers of eggs spawned, it will be seen that Nature supplies with the American variety a much larger number of eggs, in order that the deficient protection afforded them after fertilization may, as far as possible, be remedied.

It would seem that the growth of a bed and increase in the number of oysters would be immense did we not know that the greater the production of the germs in all forms of life the greater the mortality among those germs; and, therefore, any conclusions as to the impossibility of destroying the fecundity of the oyster-beds, when such conclusions are based upon the large number of eggs spawned, must be erroneous. The number of embryos surviving and maturing can not be accurately stated for either variety, as we have but four data from abroad bearing upon the question, and, until the last year, none at all from this country. Professor Möbius has collected the results of the official examinations of the Schleswig-Holstein beds, and from their inspection has come to certain conclusions, and, as these results are the only ones known to us, it may be interesting to briefly describe the method of arriving at them.

The observations were made on the beds by officials of the Government from 1730 to 1852, and were conducted in the following manner: Each bed was dredged over in three or six places, according to its size, and the oysters taken were divided into three classes and carefully counted. The classes were denominated "marketable," "medium," and "young growth." The "marketable" oysters were those full-grown and mature, from seven to nine centimetres in length and breadth, and eighteen millimetres thick. The "medium" were half-grown oysters, from sixteen to eighteen millimetres thick, and less

than nine centimetres in breadth; the "young growth" were those one or two years old.

From these observations, which were made annually, Professor Möbius discovers that there was on an average 421 medium oysters to every 1,000 marketable ones—that is, out of every 1,421 oysters 1,000 were full grown. The average of all observations differed very little from the number given by each, and consequently shows that there was but a slight fluctuation in the proportion in one hundred and twenty-two years. The "medium" oysters are considered by Professor Möbius to be those descendants of the "marketable" ones that have survived their most precarious years of existence and escaped their principal enemies, and are consequently likely to reach their full growth. They thus represent the total number of oysters spawned which have survived in the struggle for existence. From his experiments Möbius decides that about one million eggs are spawned by each oyster, and that about forty-four per cent. of the oysters on a bed spawn each season.

It is evident from the above that in an assemblage of one thousand oysters four hundred and forty million eggs would be voided every season, and of the resulting embryos four hundred and twenty-one would survive; or, 1,045,000 eggs would perish where one survived. But the "medium" oysters also spawn, though they send forth a much smaller number of eggs, and Möbius estimates that four hundred and twenty-one in the community would produce about sixty million, or the fourteen hundred and twenty-one would spawn together about five hundred million eggs, and from these five hundred million only four hundred and twenty-one oysters would be produced; or, where one oyster arrived at maturity, about 1,185,000 eggs or oysters perished!

As heretofore no examinations of the oyster-beds of this country have been made, there is no data similar to the foregoing upon which to base an estimate. As already pointed out, the mortality among the American embryo oysters must be much greater than among the European, and, in order that there might be some idea of the decrease in number and increase in size of our own variety when in the natural beds, there were deposited at various points in Tangier and Pocomoke Sounds, Maryland and Virginia, during the summer of 1879, a number of earthenware tiles as "spat"-collectors. Many of these were removed or destroyed, but from those left in place, by carefully counting at intervals the number of oysters attached, we have been able to estimate the decrease in numbers during the early months of existence.

The inspections of the "spat" collectors showed that the oysters continued attaching until about the 20th of August, and that the largest number attached about the first of that month; between the 23d of August and 10th of October the mortality was shown to be fully fifty per cent.; future examinations of the "spat"-collectors will

probably show a diminished mortality, as the animal will be better able to protect itself as it increases in size, but the destruction among the unprotected, delicate embryos must be immense, and, as it is as great as fifty per cent. after attachment, it must be much more serious prior to that event.

From observations made during the summer of 1879, I find that, on a natural, unworked bed, the ratio of young oysters, or those over one and under two years of age, to those mature and over that age, is as one to two, or in a community of fifteen hundred there would be one thousand mature and five hundred young oysters.

There is no reason to suppose that, circumstances being favorable, this entire number does not spawn, for, of all those I have examined, I have never in the spawning-season found an animal that did not contain the generative matter, or that had not recently expelled it. Numbers send forth the products of generation at unfavorable times and in either an unripe or overripe condition, and some fail to void the fluids at all, but only unfortunate combinations of natural causes have those effects; and it is probable, if not absolutely certain, that in most spawning-seasons all the animals spawn. Dr. Brooks estimates the number of eggs voided by the American oyster at from nine to sixty millions; for convenience, we may take ten millions as the average number, which is probably less than what is actually the case. The thousand mature oysters in the community would, then, spawn ten billion eggs, and, as the young European oyster has been found to spawn about one third as many eggs as the mature animal, we will consider the same to be true for the American variety. The five hundred young would, then, spawn 1,600,000,000 eggs, or the total number in the community would spawn 11,600,000,000 eggs, from which would result five hundred oysters, or about twenty million eggs or oysters would perish where one was preserved!

It is evident, then, that the vast number of eggs spawned by the oyster is no assurance that even a small proportion of them will reach maturity, or that any external or abnormal agency, natural or unnatural, may not be sufficient to destroy the beds by removing either young or old oysters, or in other ways preventing them from reproducing their kind.

My personal observations convince me that the beds of Pocomoke Sound at least are in a condition very similar to the French beds before they were subjected to the action of protective laws; and, as the French beds have, by a wise and efficient protection, been made to yield again a profitable return, it will be instructive to see how that protection is afforded. Artificial cultivation in any way is not considered, as not being pertinent, and because, in however bad a condition our own fisheries may be, the time has not yet arrived when we will be reduced to those laborious and expensive methods of obtaining a supply of oysters.

The French Government assumes control of all oyster-beds and fore-shores. As occasion may seem to require, an entire bed or part of it may be reserved from dredging for a certain time, that time being decided by the local commission. The general practice seems to be, to buoy off a third or fourth of a bed each year, which portion is only sufficiently dredged to remove weeds, mud, vermin, etc. The remainder of the bed is open to all licensed persons for a certain specified time. The following year another part of the bed is reserved, and occasionally portions are reserved for longer periods than usual. The local commission decides all matters pertaining to the beds in their vicinity, and is composed of the following officers: the inspector of the fisheries, the commander of the fishery guard, two *gardes maritimes*, and one fisherman, master of a boat.

The following are the most important regulations, made for the guidance of the commission by the Minister of Marine: The beds should not be opened for fishing until the "spat" has acquired strength to resist the action of the dredge—until the end of January, for example. When a bed has well-established breeding qualities, a fourth or fifth part of its entire area should be set apart as a reserve, and dredging over such part entirely prohibited. A fishery guard-boat should, whenever practicable, take part in the working of each bed. When a bed is foul, or encumbered with weeds or other matter noxious to the development or adherence of the "spat," it should be opened for dredging until cleaned. Beds on which there is never any production of "spat" should be opened all through the season. After the working of any bed is over, it should be carefully examined, and, if necessary, the "cultch" replenished. The close-time is between the 1st of May and 31st of August, and is strictly observed.

The above regulations and their strict observance have caused a great improvement of all the beds on the French coasts; but one instance will be sufficient to show the effects of a protective policy when understandingly conceived and rigidly enforced. In 1870, through over-fishing, the beds in the Bay of Arcachon had become entirely exhausted; but, by the strict protection afforded them, their fecundity has once more become so great (in 1876) that the waters of the bay from June until August are filled with the young swarm. On a bed, when dry at low spring ebbs, and comprising 26·7 acres, there were taken by forty or fifty persons, in some two and a half hours, about sixty thousand oysters. That part of the bed was immediately buoyed, and no more fishing allowed during the season.

Having seen what protection has been afforded the French beds, and with what success, let us see how that experience can be best used, together with such knowledge on the subject of our own fisheries as the investigations conducted during the past two years have given us. The deterioration of an oyster-bed and its impaired fecundity will be shown:

1. By the general appearance and condition of the beds and animals, the former being broken up with mud and sand among the shells, and but little healthy, growing sponge; the oysters will be large and single, the shells covered with worms, and much broken and bored in many places. Very few barnacles will be found, and the general appearance of the shells will be one of decay. 2. The ratio of "young" to "mature" oysters will be abnormally large or small; should it be greater than as two to one, or less than as one to one, it may, until we have more information on the subject, be considered abnormal. 3. The amount of *débris* in the bed will be very large, and, should it exceed fifty per cent. of the contents of the dredges, it would be unusually large. 4. The number of oysters on the beds will be found to decrease each year, though slight improvements may from time to time occur. 5. The discovery of unusual inhabitants of the beds, other than the oysters, or the disappearance of those usually found, or, in general terms, marked changes of the fauna of the beds, are an indication of deterioration.

If a bed or any number of beds present these peculiarities, in order to prevent their entire destruction it will be necessary to insure the animals some adequate protection. The best remedy for any evil is the removal of the cause; and, should the deterioration of the beds be due to excessive fishery, the prohibition of such fishery would be the readiest and most certain means of arresting the deterioration: but, as a large number of the poorer class of people is dependent, in one way or another, upon the beds, or the oyster industry, for support, it would be impossible to prohibit all fishing of any extensive area without causing great distress, and the working of the beds can consequently be only restricted and not prohibited.

As the number of dredging-vessels employed directly in the fishery is, for a time at least, constant, it follows that, the larger the area open to these workers, the less exhaustive will be the fishery of any particular locality, for the fishermen will naturally seek the most productive fields for labor, and leave old and worn-out beds for those newly discovered and well stocked. Therefore, one of the best means of affording protection to the overworked beds is the discovery of new ones, as thus without prohibitory laws the fishery will be transferred from the former to the latter. Fortunately, the area covered by oysters along the coast of the United States is so great that at present, when any bed or locality ceases to give an adequate return, the fishery is transferred to other points—as, for instance, those vessels accustomed to work in Tangier and Pocomoke Sounds have left that locality for the Potomac River and the beds in the Chesapeake bay.

In time, however, the areas covered by oysters will be known, and all future extension of the fishing-ground must be an artificial one of those known areas.

In searching for new beds they will probably be found off the

mouths of creeks or rivers, and not distant from beds already known. They generally exist as long, narrow ridges, very thickly stocked and having their greatest dimension in the direction of the current. Those areas where the bottom is sticky and the change from deep water sudden are most likely to reward a search.

The extension of the old beds can be effected by depositing suitable "cultch" upon the bottoms contiguous to the bed, and thus afford a place for the attachment of the drifting "spat." Stones, ballast, old pieces of earthenware, water-pipes, and old shells form excellent cultch, and, if any of these are scattered about the beds, a good catch may be confidently expected. Care must be taken to deposit the cultch upon those bottoms sufficiently consistent to support it, and also to make the deposit upon such areas as lie in the direction of the tidal currents, so that the young brood, rising from the natural beds, may be carried over the newly exposed cultch. If a number of mature oysters are deposited with the shells, they will materially assist in the extension of the beds. The cultch should be exposed late in the spring, so as to insure its cleanliness, as that is very desirable.

The consumption of the oyster is constantly increasing, and as the demand increases so will the disposition to fish the beds, and, should there be any failure of the supply, the increased price consequent upon that failure will induce even more exhaustive fishery; and it will become so great, if it has not already, that only strict protective laws, rigidly enforced, will be sufficient to protect the beds, and prevent the destruction of the industry.

There is, however, another means of maintaining the fecundity of the beds, which merits consideration.

During the summer of 1879, Professor W. K. Brooks was successful in securing, by artificial means, the fertilization of the eggs of the female, and in protecting the offspring for some time. Though, owing to various unforeseen combinations of natural causes, and to the accidents incidental to all tentative work, he has not been successful in maintaining the embryos until such a time as they could be deposited upon the beds with a certainty of survival, yet he has accomplished sufficient to show that the impregnation of the female cells can be easily and certainly achieved by a very simple process; and, as probably the greatest loss of the young is due to the failure of the ova to meet the male fluid at the proper time, any method which will insure such contact and protect the embryos, for even a limited period, is of great value, and well worthy of the attention of those interested in the preservation of the oyster-fishery.

Any protection afforded the young oyster assures the maturity of a greater number, and, as the beds are failing from a want of reproduction, due to the absence of mature oysters, any method which will insure the maturity of an abnormal number should be brought, if possible, to a point of practical benefit.

It would be useless to give a synopsis of the laws of the several States, so far as they relate to the oyster-fishery, as long as we are ignorant both of the condition of the beds and of the amount of observance of the law. In the locality which has been investigated an inefficient law is entirely disregarded. An oyster-guard exists, but pays no attention to the duties assigned it, and the fishery is governed solely by the demands of the market and the necessities of the oystermen. What should be done in this locality, now that the condition of the beds is known, will be apparent to any one; and the sooner other localities are subjected to a similar examination and the condition of the beds determined, the better.

So far as it is possible to give an opinion which is suitable to all localities, it would seem that any legislation looking to the protection of the oyster-beds should comprise the following:

An organized and systematic effort to discover new beds and to extend the old ones. Continued experiments, in order to ascertain the possibility of artificially raising the oysters in sufficient numbers to restock impoverished areas. The maintenance of a commission to have charge of all matters pertaining to the fishery—the commission to be composed of intelligent men, having special knowledge of the subject and allowed considerable power, and to be so appointed and constituted that their acts will be influenced by no considerations other than those for the good of the beds. Under the control of the commission should be a fishery-guard, of sufficient power and importance to enforce the regulations of the commission.

The regulations of the commission should have in view the following desired results: The prevention of exhaustive dredging. The reservation of those beds or parts of beds upon which there is a large number of young growth. The prevention of the removal of the young growth from the beds. The close observance of the close-time, which should include the outer limits of the spawning-season. The cleansing of the beds before the advent of the young brood. The exposure of suitable "cultch" when a bed has been long worked, and the destruction of starfish, drills, or other enemies that may exist on the beds.

While I am unable to say with certainty that the beds of other localities than the one I have examined have been overworked, yet I should infer that such was probably the case; and, considering the surprising results of the investigation of one locality, and one which was supposed to be the most productive in the country, if not in the world, the investigation of others can not be too soon undertaken.

The probability of all our beds arriving in time at the forlorn condition of the European oyster-banks has been foreseen, and Professor Möbius warns us of the consequence of our exhaustive fishery in the following words: "In North America the oysters are so fine and so cheap that they are eaten daily by all classes; hence they are now,

and have been for a long time, a real means of subsistence for the people. This enviable fact is no argument against the injuriousness of a continuous and severe fishing of the beds. . . . But as the number of consumers increases in America the price will also surely advance, and then there will arise the desire to fish the beds more severely than hitherto; and, if they do not accept in time the unfortunate experience of the oyster-culturists of Europe, they will surely find their oyster-beds impoverished for having defied the *bioconotic** laws."

How nearly correct he has been in his prophecy I have attempted to show, and it is with the intention of seconding his advice, and with the hope that it will be heeded, that this article has been written.

PHYSICAL EDUCATION.

By FELIX L. OSWALD, M. D.

POPULAR FALLACIES.

"A national superstition is a national misfortune. No pious fraud has ever advantaged the world, for every popular delusion becomes the mother of a noxious and numerous progeny."—HELVETIUS.

LOGICIANS distinguish between inferential and presumptive fallacies, the first being founded upon illogical conclusions from correct premises, the second upon logical conclusions from incorrect premises. With few exceptions the most mischievous popular delusions of all ages have arisen from the latter—the "presumptive" fallacies. Where their own interests are involved, men seem gifted with an instinctive faculty for looking through the tricks by which a word-juggler appears to support his sophisms with axioms known to be true, but, where that knowledge itself has been falsified (by repeating fictions till they assume the semblance of truisms), all thus biased will accept as sound whatever logical superstructure dupes or impostors may choose to erect upon such sham facts. If a man had been persuaded that cold is a panacea, he would naturally conclude that Siberia must be the healthiest country in the world. In Hindostan, where the sanctity of horned cattle is an established dogma, no true believer would hesitate to indict an irreverent bull-driver for blasphemy, or to preserve a beefsteak as a sacred relic. As long as the Bible passed for infallible, it seemed perfectly logical to ascribe diseases to witchcraft and their cure to prayer, to regard a man's natural instincts as his natural foes, to deny the difference between one and three, and treat mathematicians as enemies of the human race. The systematic application of spurious principles has led to strange

* Derived from *bioconosm*, a word signifying complete within itself.

results, and latterly to still stranger disputes concerning the propriety of acknowledging the failure, and the best way of compromising the consequences; but such controversies could often be simplified by tracing the effects to their causes. Ill-founded buildings are naturally shaky. Still, people dislike to be lectured on the chronic dilapidation of their parlor-walls. But he who succeeds in exposing the rottenness of the foundation-timbers will need no specious arguments to demonstrate the expediency of removing the household goods to a safer place.

For many centuries the training of the young was almost monopolized by the propagandists of that most terrible of all delusions, the natural-depravity dogma, and our whole system of practical education is still interwoven with the following fallacies, all more or less deeply-rooted upshots of that dogma:

1. The Leading-Strings Fallacy.—From the moment a child is born, he is treated on the principle that all his instincts are essentially wrong, that Nature must be thwarted and counteracted in every possible way. He is strapped up in a contrivance that he would be glad to exchange for a strait-jacket, kept for hours in a position that prevents him from moving any limb of his body. His first attempts at locomotion are checked; he is put in leading-strings, he is carefully guarded from the out-door world, from the air that would invigorate his lungs, from the sports that would develop his muscles. Hence, the peevishness, awkwardness, and sickliness of our young aristocrats. Poor people have no time to imitate the absurdities of their wealthy neighbors, and their children profit by what the model nurse would undoubtedly call neglect. Indian babies are still better off. They are fed on bull-beef, and kicked around like young dogs; but they are not swaddled, they are not cradled, and not dosed with paregoric; they crawl around naked, and soon learn to keep out of the way; they are happy, they never cry. If we would treat our youngsters in the same way, only substituting kisses and bread for kicks and beef, they would be as happy as kids in a clover-field, and moreover they would afterward be hardier and stronger. Every week the newspapers tell us about ladies tumbling down-stairs and breaking both arms; boys falling from a fence and fracturing their collar-bones. From what height would a young Comanche have to fall to break such bones—not to mention South-Sea Island children and young monkeys? The bones of an infant are plastic: letting it tumble and roll about would harden the bony tissue; guarding it like a piece of brittle crockery makes its limbs as fragile as glass. Christian mothers reproach themselves with neglecting their duty to their children if they do not constantly interfere with their movements, but they forget that in points of physical education Nature herself is such an excellent teacher that the apparent neglect is really a transfer of the pupil to a more efficient school.

2. The Nostrum Fallacy.—When a child complains of headache, lassitude, or want of appetite, the nurse concludes that he must "take something." If the complexion of a young lady grows every day paler and pastier, her mother will insist that she must "get something" to purify her blood. If the baby squeals day and night, a doctor is sent for, and is expected to "prescribe something." What that something should be, the parents would be unable to define, but they have a vague idea that it should come from the drug-store, and that it can not be good for much unless it is bitter or nauseous. Traced to its principles their theory would be about this: "Sickness and depravity are the normal condition of our nature; salvation can come only through abnormal agencies; and a remedy, in order to be effective, should be as anti-natural as possible." Perfectly logical from a Scriptural point of view. But Nature still persists in following her own laws. Her physiological laws she announces by means of the instincts which man shares with the humblest of his fellow-creatures, and health is her free gift to all who trust themselves to the guidance of those instincts. Health is not lost by accident, nor can it be repurchased at the drug-store. It is lost by physiological sins, and can be regained only by sinning no more. Disease is Nature's protest against a gross violation of her laws. Suppressing the symptoms of a disease with drugs means to silence that protest instead of removing the cause. We might as well try to extinguish a fire by silencing the fire-bells; the alarm will soon be sounded from another quarter, though the first bells may not ring again till the belfry breaks down in a general conflagration. For the laws of health, though liberal enough to be apparently plastic, are in reality as inexorable as time and gravitation. We can not bully Nature, we can not defy her resentment by a fresh provocation. Drugs may change the form of the disease—i. e., modify the terms of the protest—but the law can not be baffled by complicating the offense: before the drugged patient can recover, he has to expiate a double sin—the medicine and the original cause of the disease. But shall parents look on and let a sick child ask in vain for help? By no means. Something is certainly wrong, and has to be righted. The disease itself is a cry for help. But not for drugs. Instead of "*taking* something," something ought to be *done*, and oftener something habitually done ought to be *omitted*. If the baby's stomach has been tormented with ten nursings a day, omit six of them; omit tea and coffee from the young lady's *menu;* stop the dyspeptic's meat-rations, and the youngster's grammar-lessons after dinner. But open the bedroom-windows, open the door and let your children take a romp in the garden, or on the street, even on a snow-covered street. Let them spend their Sundays with an uncle who has a good orchard; or, send for a barrel of apples. Send for the carpenter, and let him turn the nursery or the wood-shed into a gymnasium. In case you have nothing but your bedroom and kitchen, there will still be room

for a grapple-swing; the Boston Hygienic Institute has patented a kind that can be fastened without visible damage to the ceiling. If the baby won't stop crying, something ought to be done about it. Yes, and as soon as possible: remove the strait-jacket apparatus, swaddling-clothes, petticoat, and all, spread a couple of rugs in a comfortable corner, and give the poor little martyr a chance to move his cramped limbs; let him roll, tumble, and kick to his heart's content, and complete his happiness by throwing the paregoric-bottle out of the window.

3. The Stimulant Fallacy.—Eight hours of healthy sleep are sufficient to restore the energy expended in an ordinary day's work. Extraordinary efforts, emotional excitement, sensual excesses, or malnutrition (either by insufficient food or dyspeptic habits), induce a general lassitude—a warning that the organism is being overtasked. Repose and a healthier or more liberal diet will soon restore the functional vigor of the system. But during such periods of their diminished activity the vital powers can be rallied by drastic drugs or tonic beverages—in other words, by poisons. The prostrate vitality rises against a deadly foe, as a weary sleeper would start at the touch of a serpent; and, as danger will momentarily overcome the feeling of fatigue, the organism labors with restless energy till the poison is expelled. This feverish reaction, dram-drinkers (patent dram-drinkers especially) mistake for a sign of returning vigor, persistently ignoring the circumstance that the excitement is every time followed by a prostration worse than that preceding it. Feeling the approach of a relapse the stimulator then resorts to his old remedy, thus inducing another sham revival, followed by an increased prostration, and so on; but before long the dose of the stimulant, too, has to be increased, the stimulator becomes a slave to his poison, and passes his life in a round of morbid excitements and morbid exhaustions—the former at last nothing but a feeble flickering-up of the vital flame, the latter soon aggravated by sick-headaches, "vapors," and hypochondria.

The stimulant habit in all its forms—"exhilarating beverages," "tonic medicines," "prophylactic bitters," etc.—is a dire delusion. A healthy man needs no artificial excitants; the vital principle in its normal vigor is an all-sufficient stimulus; the inspiration bought at the rum-shop is but a poor substitute for the spontaneous exaltations of a healthy mind in a healthy body. Playing with poisons is a losing game; the sweetness of the excitement is not worth the bitter reaction. In sickness stimulants can not further the actual recovery by a single hour. There is a strong progressive tendency in our physical constitution; Nature needs no prompter: as soon as the remedial process is finished, the normal functions of the organism will resume their work as spontaneously as the current of a stream resumes its course after the removal of an obstruction. A "prophylactic" brandy is Old Scratch in the *rôle* of an exorcist. Fevers can be prevented by

other means; and at any rate the possible danger of a climatic disease is preferable to the sure evils of the poison-drug. But how can noxious stimulants be distinguished from wholesome drinks? Tonic medicines, stimulating beverages, and poisons, are synonymous terms. Every known poison can become a lusted-after stimulant by forcing it repeatedly upon the (at first) reluctant stomach. It is true that the hankering of an old *habitué* after his tipple resembles the craving of a hungry man for food, but that constitutes no reproach against Nature, for the taste of the first drink betrayed the poison. To the palate of a child narcotic stimulants are bitter, alcohol is burning-acrid, tobacco nauseous, mineral poisons either bitter or insipid. By a liberal admixture of sugar and milk the repulsiveness of various narcotic decoctions can be diminished, but in no disguise could they be possibly mistaken for nourishing substances if the natural-depravity dogma had not weakened our confidence in the testimony of our instincts.

4. The Cold-Air Fallacy.—The influence of anti-naturalism is most strikingly illustrated in our superstitious dread of fresh air. The air of the out-door world, of the woods and hills, is, *par excellence*, a product of Nature—of wild, free, and untamable Nature—and therefore the presumptive source of innumerable evils. Cold air is the general scapegoat of all sinners against Nature. When the knee-joints of the young debauchee begin to weaken, he suspects that he has "taken cold." If an old glutton has a cramp in the stomach, he ascribes it to an incautious exposure on coming home from a late supper. Toothache is supposed to result from "draughts"; croup, neuralgia, mumps, etc., from the "raw March wind." When children have been forced to sleep in unventilated bedrooms till their lungs putrefy with their own exhalations, the *materfamilias* reproaches herself with the most sensible thing she has been doing for the last hundred nights—"opening the windows last August when the air was so stiflingly hot." The old dyspeptic, with his cupboards full of patent nostrums, can honestly acquit himself of having yielded to any natural impulse; after sweltering all summer behind hermetically closed windows, wearing flannel in the dog-days, abstaining from cold water when his stomach craved it, swallowing drugs till his appetite has given way to chronic nausea, his conscience bears witness that he has done what he could to suppress the original depravity of Nature; only once the enemy got a chance at him: in rummaging his garret for a warming-pan he stood half a minute before a broken window—to that half-minute, accordingly, he attributes his rheumatism. For catarrh there is a stereotyped explanation: "Catched cold." That settles it. The invalid is quite sure that her cough came on an hour after returning from that sleigh-ride. She felt a pain in the chest the moment her brother opened that window. There is no doubt of it—it's all the night-air's fault.

The truth is, that cold air often reveals the existence of a disease. It initiates the reconstructive process, and thus apparently the disease

itself, but there is a wide difference between a proximate and an original cause. A man can be too *tired* to sleep and too *weak* to be sick. Bleeding, for the time being, may "break up" an inflammatory disease; the system must regain some little strength before it can resume the work of reconstruction. The vital energy of a person breathing the stagnant air of an unventilated stove-room is often inadequate to the task of undertaking a restorative process—though the respiratory organs, clogged with phlegm and all kinds of impurities, may be sadly in need of relief. But, during a sleigh-ride, or a few hours' sleep before a window left open by accident, the bracing influence of the fresh air revives the drooping vitality, and Nature avails herself of the chance to begin repairs, the lungs reveal their diseased condition, i. e., they proceed to rid themselves of the accumulated impurities. Persistent in-door life would have aggravated the evil by postponing the crisis, or by turning a temporary affection into a chronic disease. But in a plurality of cases Nature will seize even upon a transient improvement of the external circumstances: a cold night that disinfects the atmosphere of the bedroom in spite of closed windows, a draught of cool air from an adjoining room, or one of those accidental exposures to wind and weather which the veriest slave of the cold-air superstition can not always avoid. For, rightly understood, the external symptoms of a disease constitute a restorative process that can not be brought to a satisfactory issue till the cause of the evil is removed. So that, in fact, the air-hater confounds the cause of his recovery with the cause of his disease. Among nations who pass their lives outdoors, catarrh and scrofula are almost unknown; not fresh air, but the want of it, is the cause of countless diseases, of fatal diseases where people are in the habit of *nailing down* their windows every winter to keep their children from opening them. "In one such den," says Dr. Bock, "I was so overcome with nausea that I could not speak till I had knocked out a pane of glass. That is about the best thing one could do in most sick-rooms"—except knocking out the whole window. The only objection to a "draught" through a defective window is, that the draught is generally not strong enough. An influx of fresh air into a fusty sick-room is a ray of light into darkness, a messenger of Vishnu visiting an abode of the damned. Cold is a disinfectant, and under the pressure of a high wind a modicum of oxygen will penetrate a house in spite of closed windows. This circumstance alone has preserved the lives of thousands whom no cough-sirup or cod-liver oil could have saved.

5. The Fever Fallacy.—Fever-and-ague, being eminently a summer disease, could not very well be ascribed to cold air; but the anti-naturalists, still resolved to find an extraneous cause, have selected as their scapegoat the only kind of natural food and drink most Christians ever touch in summer-time—fruits and cold water. The police of fever-stricken towns prohibit the sale of fresh fruit; fever-patients

are kept in sweat-boxes, asking in vain for water and fresh air; illustrated almanacs implore us to fortify our constitutions with patent brandy—"a reliable febrifuge, and in malarious districts the only safe beverage."

Considering the problem from a purely inductive standpoint, we shall find that fruits and fevers are not necessarily concomitant. Some two hundred millions of our fellow-men stick to a frugal diet in the swampiest districts of the intertropical regions, and yet enjoy a greater immunity from periodical fevers than the inhabitants of our Northern seaport towns. Siam, the Punjaub, the Brazilian forest-province of Entre-Rios, and the swampy peninsula of Yucatan, would be the healthiest regions of this planet if the absence of what we call malarial diseases could be accepted as a safe criterion; but the accounts of former travelers show that the same diseases were entirely unknown in regions which are now justly dreaded—by visitors from the North. In the valley of the Amazon, and on the larger islands of the West Indian archipelago, fevers made their first appearance with the advent of European colonists. The natives of Sierra Leone, Dr. Schweinfurth tells us, call swamp-fever the "English sickness"—a disease confined to foreigners. The Portuguese and Italians, people with a natural predilection for a frugal diet, survive where beef-eaters die by hundreds. In Mexico, where several coast-towns have become international seaports, vegetarians are almost the only permanent foreign residents; native domestics, who share the flesh-pots of their foreign employers, die by scores every summer. But the necessity of such a result might have been inferred from an *a priori* axiom which seems to have been no secret to the ancient inhabitants of Southern Europe, viz., that in a warm climate calorific food is incompatible with the constitution of the human body. The word *fever* (Latin *febris*) and its equivalents in several other languages (Greek πύρεξις, Spanish and Italian *calentura*) are derived from adjectives meaning *fervid*—hot or heated—thus indicating the chief characteristic, and, according to the ancient Greek and modern Spanish theory, also the chief cause, of all pyrexial disorders. Man is a native of the tropics, and like our next relatives, the anthropoid four-handers, our primogenitor subsisted probably on fruits and water—i. e., on a refrigerating diet. In subsequent ages several tribes of the human race emigrated to regions whose climate requires calorific food and warm clothing. On returning to the birth-land of their race these wanderers often persist in habits compatible only with a low temperature: the combined influence of a warm climate, warm clothing, and calorific food overcomes the vital power of resistance; the inability of the system to preserve its due mean temperature induces the blood-changes which characterize the symptoms of climatic fevers—the overheated blood ferments. Humid heat accelerates the disintegrating process; but that humidity is only an adjuvant and not even a necessary adjuvant cause, is

proved by the immunity of fruit-eaters in the swampiest regions of the equatorial coast-lands, as well as by the frequency of yellow-fever epidemics in such places as Vera Cruz and Pernambuco, whose neighborhood rivals that of Persepolis in sandy aridity. In other words, fevers are caused by the folly of aggravating the influence of the summer heat by superfluous clothing and calorific food (meat, greasy-made dishes, and ardent spirits), and not by fruit or cold water.

6. The Spa Fallacy.—According to the theory of the anti-naturalists, a man's instincts conspire for his ruin ; whatever is pleasant to our senses must be injurious ; repulsiveness and healthfulness are synonymous terms. To every poison known to chemistry or botany they attribute remedial virtues ; to sweetmeats, fruits, fresh air, and cold spring-water all possible morbific qualities. But, for consistency's sake, they make an exception in favor of mineral springs. Spas, impregnated with a sufficient quantity of iron or sulphur to be shockingly nauseous, must therefore be highly salubrious. Solitary mountain-regions afflicted with such spas become the favorite resort of invalids ; dyspeptics travel thousands of miles to reach a spring that tastes like a mixture of rotten eggs and turpentine. Faith does wonders, but the cure of a large proportion of the many thousands who annually visit such watering-places as Ems, Carlsbad, and White Sulphur Springs, need not be ascribed to the effects of imagination alone. The motion and the excitement of traveling exert a beneficial influence on many disorders. Mountain-air is almost a panacea. Woodland rambles, changes of diet and of general habits, conversation, and even music, are not unimportant co-agents of materia medica. But the spa itself —in the case of *bona fide* health-seekers, at least—is a decided drawback upon such advantages. Saline and sulphur springs are purgative ; the system hastens to rid itself of an injurious substance. A very small dose might operate as a moderate aperient ; but the trouble is that the digestive organs come to rely on such excitants as they would upon alcoholic tonics, hence the chronic constipations that so often follow upon the return from a watering-place trip : the stimulant being withdrawn, the organs become remiss in their functions. From a hygienic standpoint a sanitarium without a spa is therefore by no means a Hamlet-drama minus the Prince ; the mountain-air of Meran in the Tyrol or the sweet grapes of a Rhenish *Trauben-Kur* are worth a million sulphur-springs ; and, if people knew half the value of up-hill pedestrian exercise, there would be a "Hygienic Home" wherever a steep mountain overlooks a populous plain.

7. The Ascetic Fallacy.—The origin of asceticism is widely different from that of the frugal philosophy which consoles itself with the reflection that the reduction of our wants is equivalent to the enlargement of our means. A man of simple habits may be both happier and healthier than the lover of artificial luxuries, but the anti-naturalists make war upon earthly enjoyments as such ; they try to suppress

harmless as well as vicious pleasures; their aim is not the reduction but the destruction of our natural desires. The joy-loving Greeks deified even the aberrations of our natural instincts; the ascetic condemns even their legitimate gratifications. In the world of the mind as well as in the wonders of the visible creation, in streams and passions, in woods and dreams, wherever the children of Nature sought a god, the anti-naturalists feared a devil; to the exponents of asceticism life is a penalty, and earth the devil's vanity-fair, "a fleeting show, for man's illusion given." They make joy a crime, they tell us that God delights in the mortification of his creatures, in the suppression of their natural affections: "If any man hate not his father and mother and wife and children and brothers and sisters, yea, and his own life, he can not be my disciple."

But this war against Nature is the pendulum's struggle against the law of gravitation; it is the schoolboy's attempt to obstruct the sources of the Danube. Swinging left, swinging right, the pendulum must return to the middle; the stream will find its way to the valley athwart all dams, in spite of all obstructions. We can not suppress the sources of a natural instinct; all we can achieve by such attempts is to divert the stream from its normal course—to turn a natural into an unnatural passion. Education, i. e., *guidance*, does not deserve its name where it is nothing but a blind struggle against Nature. Few parents know how much easier it is to *guide* than to suppress the natural propensities of a child. Obstinate vices are often merely instincts astray, perverted energies that might be made innocuous by guiding them back to their proper sphere—perverted faculties whose abuse might have been prevented by encouraging their right use. The enemies of Nature seem to believe that an instinct can be deadened by stifling its symptoms, but the history of the last eighteen centuries has demonstrated the fallacy of that principle. They tried to stop the stream: they have only succeeded in turning it from its natural course. The attempt to suppress the pursuit of natural sciences led to the pursuit of *pseudo*-sciences—to supernaturalism, demonism, and all sorts of hideous chimeras. The monastic exiles from human society peopled their solitude with phantoms. The suppression of healthful pastimes begot a passion for vicious pastimes, and made the fancied identity of sin and pleasure a sad reality. The suppression of rational freedom has led to anarchy: the pendulum swings in the opposite direction to re-establish the due equilibrium. The ordinance of celibacy became the mother of secret vices; intolerance is the parent of hypocrisy. Wherever asceticism has trampled the flowers of this earth, the soil has produced a rich crop of weeds. The pent-up well-springs of Nature have found new outlets through dark, underground currents that could not fertilize the fields, and have undermined the foundations of many useful buildings before they could regain the light of day. Whatever liberties we now enjoy had thus to force their way through

unnatural obstructions, and the rise of our new civilization is merely the reappearance of a river which once flowed with a less turbulent and less turbid current. Yet it must flow on; all opposition has proved in vain, for each re-enforcement of the mole has also re-enforced the pressure of the waters.

Shall we persist in a hopeless endeavor? The dam-builders are still at work, but the rising stream surges with ominous eddies, constantly threatening to burst through all obstructions and cover the valley with wreck and ruin. There is only one remedy: We must reopen the natural channel. We must repair and improve its ancient banks—remove the dam that obstructs the stream, and build a dike along the shore.

The religion of the ancients exalted vice as well as Nature. Our present religion suppresses Nature as well as vice. The religion of the future will teach us to distinguish between vice and Nature.

THE RISE AND PROGRESS OF PALEONTOLOGY.*

By Professor T. H. HUXLEY, F.R.S.

THAT application of the sciences of biology and geology which is commonly known as paleontology took its origin in the mind of the first person who, finding something like a shell or a bone naturally imbedded in gravel or in rock, indulged in speculations upon the nature of this thing which he had dug out—this "fossil"—and upon the causes which had brought it into such a position. In this rudimentary form, a high antiquity may safely be ascribed to paleontology, inasmuch as we know that, five hundred years before the Christian era, the philosophic doctrines of Xenophanes were influenced by his observations upon the fossil remains exposed in the quarries of Syracuse. From this time forth, not only the philosophers, but the poets, the historians, the geographers of antiquity occasionally refer to fossils; and after the revival of learning lively controversies arose respecting their real nature. But hardly more than two centuries have elapsed since this fundamental problem was first exhaustively treated; it was only in the last century that the archæological value of fossils—their importance, I mean, as records of the history of the earth—was fully recognized; the first adequate investigation of the fossil remains of any large group of vertebrated animals is to be found in Cuvier's "Recherches sur les Ossemens Fossiles," completed in 1822; and so modern is stratigraphical paleontology, that its founder, William Smith,

* Discourse given at the York meeting of the British Association. Revised by the author.

lived to receive the just recognition of his services by the award of the first Wollaston medal in 1831.

But, although paleontology is a comparatively youthful scientific specialty, the mass of materials with which it has to deal is already prodigious. In the last fifty years the number of known fossil remains of invertebrated animals has been trebled or quadrupled. The work of interpretation of vertebrate fossils, the foundations of which were so solidly laid by Cuvier, was carried on with wonderful vigor and success by Agassiz in Switzerland, by Von Meyer in Germany, and, last but not least, by Owen in this country, while, in later years, a multitude of workers have labored in the same field. In many groups of the animal kingdom the number of fossil forms already known is as great as that of the existing species. In some cases it is much greater; and there are entire orders of animals of the existence of which we should know nothing except for the evidence afforded by fossil remains. With all this it may be safely assumed that, at the present moment, we are not acquainted with a tithe of the fossils which will sooner or later be discovered. If we may judge by the profusion yielded within the last few years by the Tertiary formations of North America, there seems to be no limit to the multitude of mammalian remains to be expected from that continent, and analogy leads us to expect similar riches in Eastern Asia whenever the Tertiary formations of that region are as carefully explored. Again, we have as yet almost everything to learn respecting the terrestrial population of the Mesozoic epoch—and it seems as if the Western Territories of the United States were about to prove as instructive in regard to this point as they have in respect of Tertiary life. My friend Professor Marsh informs me that, within two years, remains of more than one hundred and sixty distinct individuals of mammals, belonging to twenty species and nine genera, have been found in a space not larger than the floor of a good-sized room; while beds of the same age have yielded three hundred reptiles, varying in size from a length of sixty or eighty feet to the dimensions of a rabbit.

The task which I have set myself to-night is to endeavor to lay before you, as briefly as possible, a sketch of the successive steps by which our present knowledge of the facts of paleontology and of those conclusions from them which are indisputable has been attained; and I beg leave to remind you at the outset that, in attempting to sketch the progress of a branch of knowledge to which innumerable labors have contributed, my business is rather with generalizations than with details. It is my object to mark the epochs of paleontology, not to recount all the events of its history.

That which I just now called the fundamental problem of paleontology, the question which has to be settled before any other can be profitably discussed, is this: What is the nature of fossils? Are they, as the healthy common-sense of the ancient Greeks appears to have led

them to assume without hesitation, the remains of animals and plants? Or are they, as was so generally maintained in the fifteenth, sixteenth, and seventeenth centuries, mere figured stones, portions of mineral matter which have assumed the forms of leaves and shells and bones, just as those portions of mineral matter which we call crystals take on the form of regular geometrical solids? Or, again, are they, as others thought, the products of the germs of animals and of the seeds of plants which have lost their way, as it were, in the bowels of the earth, and have achieved only an imperfect and abortive development? It is easy to sneer at our ancestors for being disposed to reject the first in favor of one or other of the last two hypotheses; but it is much more profitable to try to discover why they, who were really not one whit less sensible persons than our excellent selves, should have been led to entertain views which strike us as absurd. The belief in what is erroneously called spontaneous generation—that is to say, in the development of living matter out of mineral matter, apart from the agency of pre-existing living matter, as an ordinary occurrence at the present day—which is still held by some of us, was universally accepted as an obvious truth by them. They could point to the arborescent forms assumed by hoar-frost and by sundry metallic minerals as evidence of the existence in nature of a "plastic force" competent to enable inorganic matter to assume the form of organized bodies. Then, as every one who is familiar with fossils knows, they present innumerable gradations, from shells and bones which exactly resemble the recent objects, to masses of mere stone which, however accurately they repeat the outward form of the organic body, have nothing else in common with it; and, thence, to mere traces and faint impressions in the continuous substance of the rock. What we now know to be the results of the chemical changes which take place in the course of fossilization, by which mineral is substituted for organic substance, might, in the absence of such knowledge, be fairly interpreted as the expression of a process of development in the opposite direction—from the mineral to the organic. Moreover, in an age when it would have seemed the most absurd of paradoxes to suggest that the general level of the sea is constant, while that of the solid land fluctuates up and down through thousands of feet in a secular ground-swell, it may well have appeared far less hazardous to conceive that fossils are sports of Nature than to accept the necessary alternative, that all the inland regions and highlands, in the rocks of which marine shells had been found, had once been covered by the ocean. It is not so surprising, therefore, as it may at first seem, that, although such men as Leonardo da Vinci and Bernard Palissy took just views of the nature of fossils, the opinion of the majority of their contemporaries set strongly the other way; nor even that error maintained itself long after the scientific grounds of the true interpretation of fossils had been stated, in a manner that left nothing to be desired, in the latter half of the sev-

enteenth century. The person who rendered this good service to paleontology was Nicholas Steno, professor of anatomy in Florence, though a Dane by birth. Collectors of fossils at that day were familiar with certain bodies termed "glossopetræ," and speculation was rife as to their nature. In the first half of the seventeenth century, Fabio Colonna had tried to convince his colleagues of the famous Accademia dei Lincei that the glossopetræ were merely fossil sharks' teeth, but his arguments made no impression. Fifty years later Steno reopened the question, and, by dissecting the head of a shark and pointing out the very exact correspondence of its teeth with the glossopetræ, left no rational doubt as to the origin of the latter. Thus far, the work of Steno went little further than that of Colonna, but it fortunately occurred to him to think out the whole subject of the interpretation of fossils, and the result of his meditations was the publication, in 1669, of a little treatise with the very quaint title of "De Solido intra Solidum naturaliter contento." The general course of Steno's argument may be stated in a few words. Fossils are solid bodies which by some natural process have come to be contained within other solid bodies—namely, the rocks in which they are imbedded; and the fundamental problem of paleontology, stated generally, is this: "Given a body endowed with a certain shape and produced in accordance with natural laws, to find in that body itself the evidence of the place and manner of its production."* The only way of solving this problem is by the application of the axiom that "like effects imply like causes," or as Steno puts it, in reference to this particular case, that "bodies which are altogether similar have been produced in the same way."† Hence, since the glossopetræ are altogether similar to sharks' teeth, they must have been produced by shark-like fishes; and since many fossil shells correspond, down to the minutest details of structure, with the shells of existing marine or fresh-water animals, they must have been produced by similar animals; and the like reasoning is applied by Steno to the fossil bones of vertebrated animals, whether aquatic or terrestrial. To the obvious objection that many fossils are not altogether similar to their living analogues, differing in substance while agreeing in form, or being mere hollows or impressions, the surfaces of which are figured in the same way as those of animal or vegetable organisms, Steno replies by pointing out the changes which take place in organic remains imbedded in the earth, and how their solid substance may be dissolved away entirely, or replaced by mineral matter, until nothing is left of the original but a cast, an impression, or a mere trace of its contours. The principles of investigation thus excellently stated and illustrated by Steno in 1669, are those which have, consciously or un-

* "De Solido intra Solidum," p. 5. "Dato corpore certâ figurâ prædito et juxta leges naturæ producto, in ipso corpore argumenta invenire locum et modum productionis detegentia."

† "Corpora sibi invicem omnino similia simili etiam modo producta sunt."

consciously, guided the researches of paleontologists ever since. Even that feat of paleontology which has so powerfully impressed the popular imagination, the reconstruction of an extinct animal from a tooth or a bone, is based upon the simplest imaginable application of the logic of Steno. A moment's consideration will show, in fact, that Steno's conclusion that the glossopetræ are sharks' teeth implies the reconstruction of an animal from its tooth. It is equivalent to the assertion that the animal of which the glossopetræ are relics, had the form and organization of a shark ; that it had a skull, a vertebral column, and limbs similar to those which are characteristic of this group of fishes ; that its heart, gills, and intestines presented the peculiarities which those of all sharks exhibit ; nay, even that any hard parts which its integument contained were of a totally different character from the scales of ordinary fishes. These conclusions are as certain as any based upon probable reasonings can be. And they are so, simply because a very large experience justifies us in believing that teeth of this particular form and structure are invariably associated with the peculiar organization of sharks, and are never found in connection with other organisms. Why this should be we are not at present in a position even to imagine ; we must take the fact as an empirical law of animal morphology, the reason of which may possibly be one day found in the history of the evolution of the shark tribe, but for which it is hopeless to seek for an explanation in ordinary physiological reasonings. Every one practically acquainted with paleontology is aware that it is not every tooth nor every bone which enables us to form a judgment of the character of the animal to which it belonged, and that it is possible to possess many teeth, and even a large portion of the skeleton of an extinct animal, and yet be unable to reconstruct its skull or its limbs. It is only when the tooth or bone presents peculiarities which we know by previous experience to be characteristic of a certain group that we can safely predict that the fossil belonged to an animal of the same group. Any one who finds a cow's grinder may be perfectly sure that it belonged to an animal which had two complete toes on each foot, and ruminated ; any one who finds a horse's grinder may be as sure that it had one complete toe on each foot and did not ruminate ; but, if ruminants and horses were extinct animals of which nothing but the grinders had ever been discovered, no amount of physiological reasoning could have enabled us to reconstruct either animal, still less to have divined the wide differences between the two. Cuvier, in the "Discours sur les Révolutions de la Surface du Globe," strangely credits himself, and has ever since been credited by others, with the invention of a new method of paleontological research. But if you will turn to the "Recherches sur les Ossemens Fossiles," and watch Cuvier, not speculating but working, you will find that his method is neither more nor less than that of Steno. If he was able to make his famous prophecy from the jaw which lay upon the surface

of a block of stone to the pelvis of the same animal which lay hidden in it, it was not because either he, or anybody else, knew, or knows, why a certain form of jaw is, as a rule, constantly accompanied by the presence of marsupial bones—but simply because experience has shown that these two structures are co-ordinated.

The settlement of the nature of fossils led at once to the next advance of paleontology—viz., its application to the deciphering of the history of the earth. When it was admitted that fossils are remains of animals and plants, it followed that, in so far as they resemble terrestrial or fresh-water animals and plants, they are evidences of the existence of land or fresh water, and, in so far as they resemble marine organisms, they are evidences of the existence of the sea at the time at which they were parts of actually living animals and plants. Moreover, in the absence of evidence to the contrary, it must be admitted that the terrestrial or the marine organisms implied the existence of land or sea at the place in which they were found while they were yet living. In fact, such conclusions were immediately drawn by everybody, from the time of Xenophanes downward, who believed that fossils were really organic remains. Steno discusses their value as evidence of repeated alteration of marine and terrestrial conditions upon the soil of Tuscany in a manner worthy of a modern geologist. The speculations of De Maillet in the beginning of the eighteenth century turn upon fossils, and Buffon follows him very closely in those two remarkable works, the "Théorie de la Terre" and the "Époques de la Nature," with which he commenced and ended his career as a naturalist.

The opening sentences of the "Époques de la Nature" show us how fully Buffon recognized the analogy of geological with archæological inquiries. "As in civil history we consult deeds, seek for coins, or decipher antique inscriptions in order to determine the epochs of human revolutions and fix the date of moral events, so, in natural history, we must search the archives of the world, recover old monuments from the bowels of the earth, collect their fragmentary remains, and gather into one body of evidence all the signs of physical change which may enable us to look back upon the different ages of nature. It is our only means of fixing some points in the immensity of space, and of setting a certain number of way-marks along the eternal path of time."

Buffon enumerates five classes of these monuments of the past history of the earth, and they are all facts of paleontology. In the first place, he says, shells and other marine productions are found all over the surface and in the interior of the dry land; and all calcareous rocks are made up of their remains. Secondly, a great many of these shells which are found in Europe are not now to be met with in the adjacent seas; and, in the slates and other deep-seated deposits, there are remains of fishes and of plants of which no species now exist in

our latitudes, and which are either extinct or exist only in more northern climates. Thirdly, in Siberia and in other northern regions of Europe and of Asia, bones and teeth of elephants, rhinoceroses, and hippopotamuses occur in such numbers that these animals must once have lived and multiplied in those regions, although at the present day they are confined to southern climates. The deposits in which these remains are found are superficial, while those which contain shells and other marine remains lie much deeper. Fourthly, tusks and bones of elephants and hippopotamuses are found not only in the northern regions of the Old World, but also in those of the New World, although, at present, neither elephants nor hippopotamuses occur in America. Fifthly, in the middle of the continents, in regions most remote from the sea, we find an infinite number of shells, of which the most part belong to animals of those kinds which still exist in southern seas, but of which many others have no living analogues; so that these species appear to be lost, destroyed by some unknown cause. It is needless to inquire how far these statements are strictly accurate; they are sufficiently so to justify Buffon's conclusions that the dry land was once beneath the sea; that the formation of the fossiliferous rocks must have occupied a vastly greater lapse of time than that traditionally ascribed to the age of the earth; that fossil remains indicate different climatal conditions to have obtained in former times, and especially that the polar regions were once warmer; that many species of animals and plants have become extinct; and that geological change has had something to do with geographical distribution.

But these propositions almost constitute the framework of paleontology. In order to complete it but one addition was needed, and that was made, in the last years of the eighteenth century, by William Smith, whose work comes so near our own times that many living men may have been personally acquainted with him. This modest land-surveyor, whose business took him into many parts of England, profited by the peculiarly favorable conditions offered by the arrangement of our secondary strata to make a careful examination and comparison of their fossil contents at different points of the large area over which they extend. The result of his accurate and widely extended observations was to establish the important truth that each stratum contained certain fossils which are peculiar to it; and that the order in which the strata, characterized by these fossils, are superimposed one upon the other is always the same. This most important generalization was rapidly verified and extended to all parts of the world accessible to geologists; and now it rests upon such an immense mass of observations as to be one of the best established truths of natural science. To the geologist this discovery was of infinite importance, as it enabled him to identify rocks of the same relative age, however their continuity might be interrupted or their composition altered. But to the biologist it had a still deeper meaning, for it demonstrated

that, throughout the prodigious duration of time registered by the fossiliferous rocks, the living population of the earth had undergone continual changes, not merely by the extinction of a certain number of the species which at first existed, but by the continual generation of new species, and the no less constant extinction of old ones.

Thus, the broad outlines of paleontology, in so far as it is the common property of both the geologist and the biologist, were marked out at the close of the last century. In tracing its subsequent progress I must confine myself to the province of biology, and indeed to the influence of paleontology upon zoölogical morphology. And I accept this limitation the more willingly as the no less important topic of the bearing of geology and of paleontology upon distribution has been luminously treated in the address of the President of the Geographical Section.

The succession of the species of animals and plants in time being established, the first question which the zoölogist or the botanist had to ask himself was, "What is the relation of these successive species one to another?" And it is a curious circumstance that the most important event in the history of paleontology which immediately succeeded William Smith's generalization was a discovery which, could it have been rightly appreciated at the time, would have gone far toward suggesting the answer, which was in fact delayed for more than half a century. I refer to Cuvier's investigation of the mammalian fossils yielded by the quarries in the older Tertiary rocks of Montmartre, among the chief results of which was the bringing to light of two genera of extinct hoofed quadrupeds, the *Anoplotherium* and the *Palæotherium*. The rich materials at Cuvier's disposition enabled him to obtain a full knowledge of the osteology and of the dentition of these two forms, and consequently to compare their structure critically with that of existing hoofed animals. The effect of this comparison was to prove that the *Anoplotherium*, though it presented many points of resemblance with the pigs on the one hand, and with the ruminants on the other, differed from both to such an extent that it could find a place in neither group. In fact, it held, in some respects, an intermediate position, tending to bridge over the interval between these two groups, which in the existing fauna are so distinct. In the same way, the *Palæotherium* tended to connect forms so different as the tapir, the rhinoceros, and the horse. Subsequent investigations have brought to light a variety of facts of the same order, the most curious and striking of which are those which prove the existence, in the Mesozoic epoch, of a series of forms intermediate between birds and reptiles—two classes of vertebrate animals which at present appear to be more widely separated than any others. Yet the interval between them is completely filled, in the mesozoic fauna, by birds which have reptilian characters on the one side, and reptiles which have ornithic characters on the other. So, again, while the group of

fishes termed ganoids is at the present time so distinct from that of the dipnoi or mud-fishes that they have been reckoned as distinct orders, the Devonian strata present us with forms of which it is impossible to say with certainty whether they are dipnoi or whether they are ganoids.

Agassiz's long and elaborate researches upon fossil fishes, published between 1833 and 1842, led him to suggest the existence of another kind of relation between ancient and modern forms of life. He observed that the oldest fishes presented many characters which recall the embryonic conditions of existing fishes; and that, not only among fishes, but in several groups of the invertebrata which have a long paleontological history, the latest forms are more modified, more specialized, than the earlier. The fact that the dentition of the older tertiary ungulate and carnivorous mammals is always complete, noticed by Professor Owen, illustrated the same generalization.

Another no less suggestive observation was made by Mr. Darwin, whose personal investigations during the voyage of the Beagle led him to remark upon the singular fact that the fauna which immediately precedes that at present existing in any geographical province of distribution presents the same peculiarities as its successor. Thus, in South America and in Australia, the later tertiary or quaternary fossils show that the fauna which immediately preceded that of the present day was, in the one case, as much characterized by edentates and in the other by marsupials as it is now, although the species of the older are largely different from those of the newer fauna.

However clearly these indications might point in one direction, the question of the exact relation of the successive forms of animal and vegetable life could be satisfactorily settled only in one way—namely, by comparing, stage by stage, the series of forms presented by one and the same type throughout a long space of time. Within the last few years this has been done fully in the case of the horse, less completely in the case of the other principal types of the ungulata and of the carnivora, and all these investigations tend to one general result—namely, that in any given series the successive members of that series present a gradually increasing specialization of structure. That is to say, if any such mammal at present existing has specially modified and reduced limbs or dentition and complicated brain, its predecessors in time show less and less modification and reduction in limbs and teeth and a less highly developed brain. The labors of Gaudry, Marsh, and Cope furnish abundant illustrations of this law from the marvelous fossil wealth of Pikermi, and the vast uninterrupted series of tertiary rocks in the Territories of North America.

I will now sum up the results of this sketch of the rise and progress of paleontology. The whole fabric of paleontology is based upon two propositions: the first is, that fossils are the remains of animals and plants; and the second is, that the stratified rocks in which

they are found are sedimentary deposits; and each of these propositions is founded upon the same axiom that like effects imply like causes. If there is any cause competent to produce a fossil stem, or shell, or bone, except a living being, then paleontology has no foundation; if the stratification of the rocks is not the effect of such causes as at present produce stratification, we have no means of judging of the duration of past time, or of the order in which the forms of life have succeeded one another. But, if these two propositions are granted, there is no escape, as it appears to me, from three very important conclusions. The first is, that living matter has existed upon the earth for a vast length of time, certainly for millions of years. The second is that, during this lapse of time, the forms of living matter have undergone repeated changes, the effect of which has been that the animal and vegetable population at any period of the earth's history contains some species which did not exist at some antecedent period, and others which ceased to exist at some subsequent period. The third is that, in the case of many groups of mammals and some of reptiles, in which one type can be followed through a considerable extent of geological time, the series of different forms by which the type is represented at successive intervals of this time is exactly such as it would be if they had been produced by the gradual modification of the earliest form of the series. These are facts of the history of the earth guaranteed by as good evidence as any facts in civil history.

Hitherto I have kept carefully clear of all the hypotheses to which men have at various times endeavored to fit the facts of paleontology, or by which they have endeavored to connect as many of these facts as they happened to be acquainted with. I do not think it would be a profitable employment of our time to discuss conceptions which doubtless have had their justification and even their use, but which are now obviously incompatible with the well-ascertained truths of paleontology. At present these truths leave room for only two hypotheses. The first is that, in the course of the history of the earth, innumerable species of animals and plants have come into existence, independently of one another, innumerable times. This, of course, implies either that spontaneous generation on the most astounding scale, and of animals such as horses and elephants, has been going on, as a natural process, through all the time recorded by the fossiliferous rocks; or it necessitates the belief in innumerable acts of creation repeated innumerable times. The other hypothesis is, that the successive species of animals and plants have arisen, the later by the gradual modification of the earlier. This is the hypothesis of evolution; and the paleontological discoveries of the last decade are so completely in accordance with the requirements of this hypothesis that, if it had not existed, the paleontologist would have had to invent it.

I have always had a certain horror of presuming to set a limit upon the possibilities of things. Therefore, I will not venture to say that

it is impossible that the multitudinous species of animals and plants may have been produced one separately from the other by spontaneous generation, nor that it is impossible that they should have been independently originated by an endless succession of miraculous creative acts. But I must confess that both these hypotheses strike me as so astoundingly improbable, so devoid of a shred of either scientific or traditional support, that even if there were no other evidence than that of paleontology in its favor, I should feel compelled to adopt the hypothesis of evolution. Happily, the future of paleontology is independent of all hypothetical considerations. Fifty years hence, whoever undertakes to record the progress of paleontology will note the present time as the epoch in which the law of succession of the forms of the higher animals was determined by the observation of paleontological facts. He will point out that, just as Steno and as Cuvier were enabled from their knowledge of the empirical laws of coexistence of the parts of animals to conclude from a part to the whole, so the knowledge of the law of succession of forms empowered their successors to conclude, from one or two terms of such a succession, to the whole series, and thus to divine the existence of forms of life, of which, perhaps, no trace remains, at epochs of inconceivable remoteness in the past.

STUDIES OF VORTEX-RINGS.

By ADRIEN GUÉBHARD.

MAKING skip-rings in the water, and gazing at the vapors in the air, furnish common expressions for complete inactivity and vacuity. Yet, in these occupations may be found subjects of profound and worthy studies. Nothing is vulgar to one who knows how to see, nothing indifferent to one who knows how to observe; and the fall of a drop of water, insignificant as we may regard it, may bring us into the neighborhood of the ultimate mysteries of those regions to which the fall of an apple once transported the immortal genius of Newton. As profitable subjects for study may be found in those common rings, simple wrinkles on the surface of the water, in which the physicist sees many things and the clown few; or, in those turbid clouds of smoke which every day float toward the sky from our fires here below.

Everybody has seen some adroit smoker throw from his mouth or his pipe pretty, white wreaths, whose whirling vapors it was a pleasure to follow in the air.* It is a fact of daily observation that

* Fig. 1 has been designed after the celebrated picture of Brauwer in the Lacaze Gallery of the Louvre. In the original, the picture only represents a spiral of smoke. But the form of the mouth and the convergence of the eyes sufficiently indicate the helpless effort of the drunken man. The subject seems to have been a favorite one with the

a drop of soap and water dropping from the end of the fingers spreads out in the basin into the form of a perfect ring that gradually increases as it descends toward the bottom.

Why do the light particles, instead of scattering promiscuously in the liquid or gaseous medium, take this special state of mobile equilibrium and regular grouping? Why this form so fragile in appearance, instead of any other more simple and possibly more stable? Is it by pure chance or by pure direction? And, if the latter is the case, what is the secret of it? It will not be difficult to detect the secret in a short time, and a few words will show that we have here, not an exceptional and rare case, but a general law of nature, common examples of which exist under our eyes.

FIG. 1.—WREATHS OF TOBACCO-SMOKE. (From Brauwer's picture in the Lacaze Gallery, Louvre.)

Wreaths of the same shape are often seen to issue from the mouths of cannon when they are fired off; I have seen them following the locomotive of an express-train. Any one who has pursued a course in chemistry may remember the beautiful experiments in which bubbles of phosphoretted hydrogen take fire spontaneously as they rise to the surface of the basin, and develop superb wreaths of white fumes.

old Flemish painters, for it recurs under all sorts of forms, either as a detail or as the principal motive in ten, at least, of Teniers's pieces, and in another Brauwer in the gallery at Madrid.

Nature herself sometimes produces this phenomenon without any human intervention, and shows us the vortices of the *ignis fatuus*, to which the middle ages attached so many poetical legends, rising on summer evenings from the stagnant waters of marshes. The craters of volcanoes also frequently give off smoke in the form of magnificent ring-clouds.

Huygens observed, with one of the first telescopes, the annular form of those curious satellites of Saturn, the singular equilibrium of which is still a subject of discussion. The periodical November meteors form a real ring of planetary fragments around the earth; everything seems to prove that the milky way is nothing but a gigantic ring of cosmic dust, of which our sun and its satellites are only a few grains; the question of the form of the zodiacal light is hardly doubtful; and, finally, among the infant worlds that we call nebulæ, the annular figure recurs with such frequency that it can no longer be considered exceptional; and the inspiration of genius which caused Laplace to see in the fracture of such a ring the whole origin of our solar system is reflected in the broken rings which are found among some of these nebulæ.

The laws of nature, however, frequently reveal themselves best in the infinitely little; and I have made my first observations toward a new study in watching the filiform currents produced during the osmotic interchange of two liquids through the pores of a membrane.*

While intimately regarding the curious phenomena with which Ducrochet sought to connect all the laws of life, I devised a way to observe the current of osmose, if I may so speak, in the act. This is not easily done with alcohol or water, but, by carefully taking advantage of the refracting and magnifying properties of cylindrical glasses, I succeeded, at last, in distinguishing before either very dark or very light grounds, slight, thin trains indicative of movement; and it was really a curious phenomenon to see two liquids of so strong affinities for each other, brought into intimate contact through a permeable membrane, obeying the laws of gravity almost without mixing, and taking their course across each other in the form of distinct threads, which presented at the same time the sharpness and the apparent fixity of a fiber of pure glass. The figure of these threads is not constantly stationary, but is subject to a regular movement, in which periodically, while still preserving its individuality, it seems to undergo alternate swellings and attenuations that give it the appearance from a certain distance of shafts of columns put one upon the other, of larger and larger capitals, or of pointed parasols, or Chinese hats with several crowns. If we look at them from above, we may perceive, in these spirals and expansions, the profiles of real circular rings, slightly attached by an invisible cord to a central stalk which bears them

* "Études sur l'osmose de l'alcool à travers la gutta-percha" (C. R. de l'Assoc. France, Montpellier, 1879).

in groups of two or three, and animated by special movements. A section of the chain along its axis of revolution gives the forms represented in Fig. 2, A. The superposed forms of the figure, A, are evidently only the successive phases of a single drop as emitted at each pulsation; and all our efforts should be directed to isolating the drops and retarding their descent, so as to make them

FIG. 2.—FORMS OF A COLORED DROP PENETRATING A COLORLESS LIQUID.

more visible under their different aspects. This is easily done. A variety of colored liquids are at our disposal, and, with a little alcohol, or a trace of glycerine or sugar, we may modify insensibly the density of the liquids, reduce the action of gravity to a minimum, and have at will ascending or descending currents. The last are generally easiest to obtain. Fig. 3 represents a simple apparatus for the experiment, the operation of which is dependent on the familiar principle of the siphon: we have only to raise the level of the colored liquid in the glass to change the rate of flow as we may wish. Certain manual difficulties in handling this apparatus may be obviated by using a system of communicating vessels, such as may be made by taking a common lamp-chimney, corking up the lower part and putting it in communication, by means of a pipe inserted in the cork and an India-rubber tube, with the bottom of a similar vessel or the nozzle of a vertical funnel. A string around the tube, or a pair of nippers, may serve to regulate the flow of the colored liquid, which should be only a little less dense than the other; and by inclosing a bubble of air above this liquid and covering the top of the chimney with a membrane, we may vary the pressure without changing the level of the liquid. If we have

not a glass tube at hand, we may make the communication by means of a fine bird's-quill, or a thin straw of grass, or even by a pinhole pierced in a piece of membrane. Having brought the orifice and the surface of separation of the two liquids to the same level, if we give a gentle push, we may see issue a kind of swelled fungus with a short

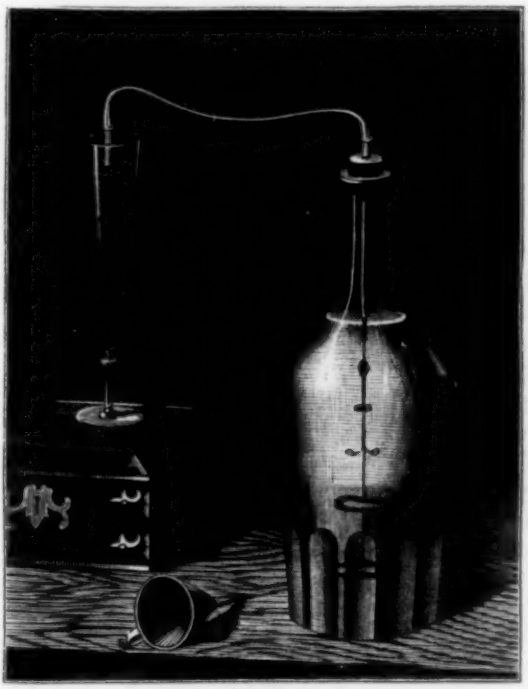

FIG. 3.—ARRANGEMENT OF AN APPARATUS FOR THE STUDY OF VORTICAL VEINS IN LIQUIDS.

stem (Fig. 2, C 1), on the edges of which a backward rotation is immediately manifested, an evident sign of the resistance and friction of the ambient mass. Hardly is the drop detached from the tube before we see it widening on its stem and becoming hollow below (Fig. 2, C 2); the edges fold back and soon take the motion of a winding scroll, which seems to attract to itself the lingering part of the colored filament (Fig. 2, C 3). Once begun, this whirling motion is continually kept up by the friction, which, upon the exterior contours, exhausts a little of the acquired velocity. The whole substance of the drop will pass into it, and with it numerous molecules of the uncolored liquid, the interposed layers of which will assist in supporting the geometrical rolling up of the steadily growing spirals. It is really an endless reeling, a stretching out into a surface of the whole of a little liquid mass; so that finally (Fig. 2, C 4) the line of the front appears as only a minutely fine thread, which is destined to burst under the strain of the

tension of the whole contour. At length (Fig. 2, C 5) we find ourselves in the face of that curious form of mobile equilibrium of fluids of which we have noticed so many examples, and of which we have in a manner just studied the genesis and the anatomy. These singular wreaths have a still more singular constitution than we conceive; they are not full rings, nor even such simple hollow rings as we might make by bringing together the ends of an India-rubber tube. We have to

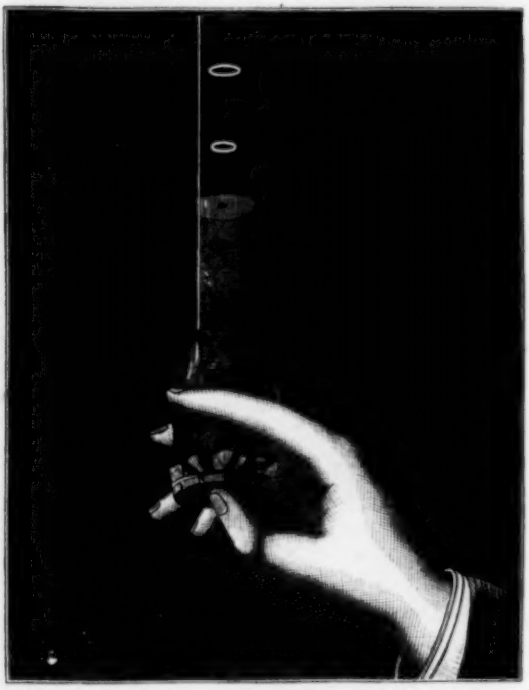

FIG. 4.—A LAMP-CHIMNEY, closed by a membrane at its lower end, with a perforated disk in the middle, and half filled with tobacco-smoke; a push of the thumb on the membrane causes rings of smoke to issue through the orifice of the disk in the middle.

imagine a continuous necklace of watch-springs locked one to another along a circle, by which all their ends are joined; or, to speak geometrically, the figure of revolution which would be produced by a plane spiral turning round an asymptotic axis. Observation shows, together with a delicacy of design in the shaft, and a transparency which nothing can excel, fine horizontal striæ passing from one volute to another, and marking with exceeding neatness the number and divergence of the rollings. In water, effects of exquisite beauty may be produced directly without passing through the intermediate phases, by means of taps on the membrane of the apparatus. The experiment may again be simplified by forming with the membrane itself the bottom of the vessel, and using for an orifice a hole pierced in a disk which has been

forced down tight into the middle of the tube. This instrument gives at each expulsion of the colored ring a corresponding return ring, a kind of negative ring, that descends clear in the interior of the colored liquid, or *vice versa*, if it is the liquid in the upper part that has been colored. The same phenomena appear when smoke is used, as in Fig. 4. We may dispense with all apparatus and let fall from the height of about an inch a lightly tinted drop into a still colorless mass. From this experiment chemists learned, even before Trowbridge explained the theoretical reason for it, that it was best to employ liquids differing but little from each other, or at least such as were easily diffusible in each other. Reusch, however, has described some very unstable rings of oil in water that may be produced with an apparatus similar to ours. It is interesting, in view of the cosmic examples to which we have referred, that after the oil of the upper compartment has been replaced with water, each jet carries along from the borders of the tubing myriads of little oily drops, the drift of which renders visible in the interior of the clear water the annular constitution of the vortex formed by the irruption of a mass of absolutely identical liquid. The generality of the fact may be verified with an emulsion of ginger, or simply with superficial dust on the brightly lighted bottom of a white porcelain plate.

Imperceptible grains of coloring substance, put upon the surface of the water, immediately give rise to fine descending trains, which permit us to detect in the phenomena of solution the same character of intermittence and discontinuity that marks that of osmose. A penful of ink, a bit of sugar, a thousand simple means of observing the development of vortices, may be suggested. A piece of thread, hanging from a glass filled to the brim, makes an excellent capillary siphon, and furnishes perfect continuous movements, so that, unless the liquid is superficially stirred, or the lower glass is shaken, we obtain trains of provoking fixity, that follow their determined route without giving a pulsation to betray their interior motion. Of this character are the upright columns of mist that rise from the calm plain of the desert. So a flexible thread, carried by a balloon, revolves in the breath of the wind without breaking. The direction of a straight line is not an essential one; and, if the density of the liquid happens to be variable, the thread takes the form of an elongated spiral, the curves of which are alternately narrower and wider, and end in scrolls resembling foliage or florescence. These phenomena are not transient, but may last for days, although the rings we have been considering continue only for a few moments, and, while they present a real elasticity of form as long as they are in motion, never survive the loss of the impulse that produced them. Most frequently denser nuclei appear in their interior, which take the lead, and descend as if suspended from elastic arches, of which they draw out long branches (Fig. 2, B). Each of these nuclei appears to undergo, in its interior, the different transformations

of Fig. 2, C, till a little secondary ring is formed, which sometimes remains attached, is at other times separated and divided into several others, that will, if they are small enough, continue for a long time suspended in the liquid.

All of these little rings, with the curved filaments supporting them, form in the water a very marked figure—a kind of diadem, a fantastic hydra, or a diaphanous cup (Fig. 2, B)—the singular figure of which causes us to neglect at first certain less visible details in which the real mechanism of the phenomenon is revealed; and a very light or a very dark ground, according to the character of the colored liquid, is required in order to discover the frame-work and the processes of the formation.

Rings of vapor are capable of attaining considerable dimensions without breaking. If we take a box, make a hole in it, substitute a stretched cloth or plate of metal for one of its sides, and develop in it vapors of phosphoric acid or muriate of ammonia, we can easily by

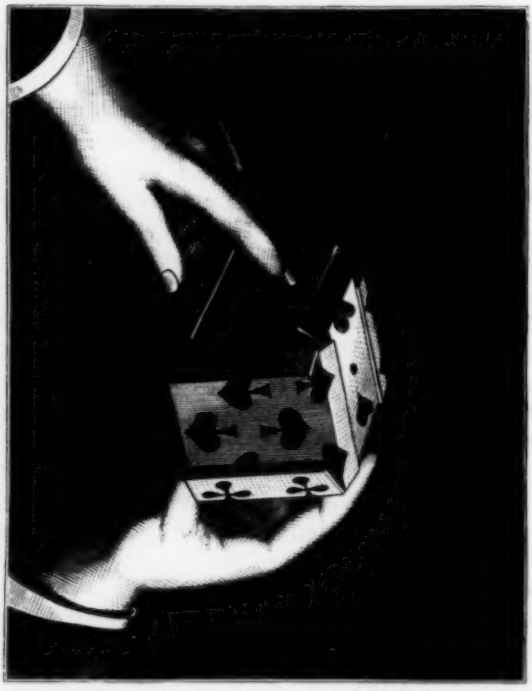

FIG. 5.—The same experiment, performed with a box made of playing-cards. The box is filled from the mouth at the hole in the upper side.

means of a slight blow cause wreaths several inches in diameter, exhibiting the structural details of the liquid rings, to shoot out to a considerable distance. A soap-bubble filled with smoke produces similar effects when it bursts; and a cubic box made of playing-cards

(Fig. 5) will enable us to study, with the help of tobacco-smoke, how little influence the shape of the opening has upon the rings which we drive out through the hole at which we have filled the box. We may make the hole square or rectangular; or, if we cut certain combinations of long slits or several holes, those composite forms which Thomson has described as vibrating rings will be produced.

If two rings are sprung in succession, they will constantly tend to overtake each other and cross each other alternately in a curious play of approaches and withdrawals, but always with some damage to each other if they are large; and this property is best studied in liquids. Two equal vortices shot from different boxes will play with each other indefinitely, and the same happens when they strike the wall. But, if they pass each other, only grazing their edges, they will merely change shape without breaking and without getting out of the way, and then immediately bound back to their original form like an India-rubber spring. This power of resistance, or power of annular elasticity, is the most striking characteristic of these singular forms, real magazines of energy, in which all the living primitive force collects itself under the influence of external friction. Theoretically, the vortical movement, in a perfect fluid, can neither be created nor destroyed; eternal as matter itself, it has neither beginning nor end. The vortex-ring is indivisible. Attack it as quickly as you will, says Professor Tait, cut at it with the sharpest knife, you can never sever it or mar it; but, flying away or enveloping the material object, it remains whole, always itself; and, when we consider its wonderful properties, we need hardly be surprised that philosophers have aspired to build up upon it theories of the constitution of matter, and of the origin of all the physical forces, from gravitation to electricity.

We conclude with the citation of an extremely simple experiment described by Helmholtz: If we draw the rounded end of a spoon or a knife over the surface of a liquid, we may produce all around a vortical agitation giving the form of a vertical half-ring, the internal contour of which corresponds with the semicircular edge of the solid object, while on the right and left, on the surface of the liquid, appear two portions of the same diametrical section, which should reproduce the schemes of Fig. 2, C. Quite plain, in effect, are the scrolls designed on the dark surface of a cup of coffee by the white trains of the cream; and it is very easy to study thus all the mutual reactions of these vortices, similar as they are to those which the waterman sees running along the edge of his oar, and which can be reproduced of satisfactory dimensions on the surface of a bath-tub. Such experiments are within the reach of every one.—*La Nature.*

EQUALITY AND INEQUALITY IN SEX.

By G. DELAUNEY.

THE sentimental pretensions put forward by a political school which holds that woman is intellectually the equal of man, give a character of actuality to the question of the comparison of the sexes. This question, which it has been the custom to treat from a metaphysical point of view, is to us purely anthropological, or rather zoölogical; for we propose to show by characteristic examples borrowed from the whole animal kingdom that sexuality undergoes the same evolution in all species, including the human species. The female surpasses the male in certain inferior species. The males are smaller than the females among many cephalopods, and among some cirripeds. With a few exceptions, the superiority of the females prevails among the annelids, and among certain articulates, as bees, hornets, wasps; and female butterflies are larger and heavier than males, a difference being observable even among the larvæ. A like superiority of females may be observed in many fishes, as in the cyprinoids, and in reptiles. This is, however, no longer the case among the superior vertebrates. The males of birds and mammals are nearly always superior to the females.

To sum up, the two sexes, at first unequal in consequence of the superiority of the female over the male characterizing the lowest species, become equal among species a little more elevated in the animal scale, and become unequal again in consequence of the pre-eminence of the male over the female, which is observed in all the higher species. The supremacy of the female is, then, the first term of the evolution which sexuality undergoes, while the supremacy of the male is the last term. Let us now see wherein the superiority of the male is manifested.

The nutritive phenomena in birds and mammals, including the human species, are more intensive in the male than in the female. The blood is denser, redder, contains more red globules and hemiglobine (Quinquand, Korniloff), fewer white globules, and less water. M. Malassez has found a million more red globules in a cubic millimetre of man's than of woman's blood. Man eats more than woman. Public charities recognize that it costs more to feed a boy than a girl. But, though she eats less, woman is more of a gourmand (Brillat-Savarin), and eats more frequently, being oftener pressed by hunger. Women in the cities eat between-meals, like children. In asylums for the aged, where women are not allowed more meals than men, they abstract food from each meal to eat in the intervals, so as to double the number of their meals.

The respiratory phenomena of men are also stronger than those of women. The pulmonary capacity of a woman is a pint less than that

of a man of the same size. The thoracic index of woman is less than that of man (Weisgerber). The man absorbs more oxygen, although he does not breathe as often. According to Quetelet, the woman, from fifteen to fifty years of age, makes one more inspiration a minute than the man. At all ages man exhales more carbonic acid than woman (Andral and Gavarret). The temperature of man is higher than that of woman. In the circulation, the pressure of the blood is stronger in the male, although the pulse is less frequent. The difference amounts to eighteen pulsations a minute in the lion, ten in cattle, twelve in sheep, and ten to fourteen in man.

The relative weight of the skeleton to the total weight of the body is less with woman; Topinard says that in the physical characters of her skeleton woman is intermediate between the infant and the masculine adult. M. Milne-Edwards has found the bones of the male a little richer in inorganic matter than those of the female, and that at thirty years the bones of the man contain more mineral matter, less organic matter, more carbonate of lime, less phosphate of lime, than those of the woman. The prevalence of the right side over the left is less with the woman (Harting). Broca has found that the clavicle of the woman is longer in proportion to the humerus; similar differences are observed between inferior and superior races.

The male individual is always larger than the female. This is observable in our domestic animals. M. Topinard fixes the average difference in height between man and woman at twelve centimetres (four and two thirds inches). Woman is also lighter than man, although she often appears larger on account of the greater development of her adipose system. Topinard says that in the whole Indo-European series woman is more prognathous than man. According to my researches the foot of woman is flatter and less arched than that of man, a fact which women of fashion try to hide by means of high heels. The female voice is always higher than that of the male, in animals and in man. Woman's voice is an octave higher than man's.

The muscular system of the male is better developed and more vigorous than that of the female. This may be observed in wild and domestic animals. The muscular force of a woman from twenty-five to thirty years of age, measured in the dynamometer, is a third less than that of a man of the same age. The movements of man are more precise than those of woman. Thus men make the best pianists. The skull of the male is more voluminous than that of the female (Sömmering, Parchappe, Broca, Morselli). Huschke estimates the difference in Europeans at two hundred and twenty cubic centimetres, Dr. Weisbach makes the relative measurement as 1,000 to 878; Morselli, 100 to 85. The shape of the skull also varies with the sex, that of the man being lower and longer than that of the woman. The brain of the male is heavier than that of the female, in a proportion for man fixed by Broca at 1,323 to 1,210 grammes (46¾ to 42¼ ounces).

Parchappe makes the difference as 109·34 to 100, Broca ; Rudolph, and Wagner, as 111 to 100 ; Huschke, as 112 to 100 ; Meyner, as 100 to 90. That this difference in weight does not depend upon the relatively smaller size of woman is shown by the statement of Parchappe, that while the stature of woman is to that of man as 927 to 1,000, the relative weight of the brains of the two sexes is as 909 to 1,000. M. Le Bon has found, on comparing the average weight of the brains of seventeen men of about five feet in height with that of the brains of seventeen women of corresponding size, a difference of one hundred and seventy-two grammes (six and one quarter ounces) in favor of the masculine brain. Diagrams of the feminine brains of different races show that even in the most intelligent populations, as among contemporary Parisians, the skulls of a notable proportion of women more nearly approach the volume of the skulls of certain gorillas than that of the better developed skulls of the male sex.

Other differences between the brains of the two sexes relate to the conformation. According to Broca, Wagner, and Huschke, and Wight, of New York, the frontal lobes, the seat of the highest intellectual faculties, are less developed in woman than in man. The occipital lobes, the seat of the sentiments, are more voluminous in woman. According to Professor Wagner, the brain of woman as a whole is always in a more or less embryonic condition. Huschke says that woman is only a child in growth, and belies her infantine type no more by her brain than by the other parts of her body. Some anatomists allege that the right side of the brain is superior in women and the left side in men ; hence women pass to the left and men to the right. I have observed that man performs certain motions, as those of striking and buttoning the clothes, centrifugally, and woman centripetally—another sign of inferiority in woman.

The differences in the relative prominence of the lobes of the brain may explain why woman is more given to the life of the heart and man to that of the mind, a point in which all authors are agreed.

The question of the relative morality of the sexes has been debated by thousands of authors. Without going over their ground, we will endeavor to show what light has been cast upon it by recent facts in demography. Women incontestably commit a smaller proportion of crimes against persons than men. Quetelet suggests that they are more restrained by shame and modesty, by their condition of dependence, their more retired habits, and their physical weakness. When they do thus offend, they are more apt to adopt poisoning, the weapon of cowards. It is universally admitted, again, that woman is more devout and more charitable than man. Her charity is, however, it may be said, often narrow and intolerant, and exercised for the sake of proselytism.

We now come to the consideration of the intellectual faculties. The male is more intelligent than the female in all the superior species.

Trainers of trick-dogs prefer males. Regarding the human species, all known systems of legislation recognize an intellectual inferiority of the female sex to the male, and treat woman as a minor not able to take care of herself, and needing a guide and tutor. The allotment of this position to woman has been determined chiefly by her levity and frivolity, and the Roman law constantly invokes *fragilitatem sexus* in justification of its statutes. The partisans of equality meet this fact by alleging that the laws have sacrificed woman because they were made by men. Moralists have also noticed that women are merrier, more changeable, and more capricious than men; they are likewise more heedless and less circumspect. All philosophers and moralists admit that women are more superstitious, more prepossessed, more imitative, and more addicted to routine, more talkative, and more timid, than men. Some men of science also hold that women are less intelligent than men. Broca says they are a little less so. Darwin remarks that men go further than women in all that they undertake where profound thought, reason, imagination, or the application of the senses and the hands are concerned, and that if we should draw up a list of the dozen men and a similar list of the dozen women most distinguished in poetry, painting, sculpture, science, and philosophy, the two lists would bear no comparison. We might also cite the opinion of manufacturers and merchants who, employing both sexes, have been able to compare their faculties. All those whom we have consulted think women are more assiduous but less intelligent than men. In printing-offices, for example, women work minutely, mechanically, without knowing very well what they are doing. They succeed well in reprint, which does not exact intelligence, and poorly in manuscript.

In the evolution of tastes and ideas, woman marches about a century behind man. One might say that she is in the course of going through the phases that we have passed in arts, letters, science, and philosophy. The artistic and literary paths which man is abandoning for the scientific road are now taken possession of by the female sex. According to the librarians and the directors of reading-rooms, while the men are interested in the study of history, philosophy, and science, the women are still inquiring for novels. It is, however, just to add that Europe and America possess a few doctresses, and that a day will perhaps come when scientific careers will be disputed by women. We are not authorized to conclude, from the fact that they have not yet figured as inventors, that they will always be incapable of discovering anything. The future only can tell whether woman is simply an imitator, or whether she is a creator in the same sense as man.

It results as a whole from this parallel between the sexes that, among the superior species, the male excels the female not only in the intensity of the nutritive phenomena, but also in muscular force and intellectual development; because man, more strongly nourished than woman, fabricates more force than she, he is correspondingly stronger

in physical and intellectual qualities than she. It may be added that more biological differences are found between the males than between the females of the same race. If, for example, we take ten Crèvecœur cocks, we shall find that they differ much more from each other in size and the development of the locomotive organs than ten hens of the same variety. So, in the human species, regarding the stature, color of hair, muscular strength, voice, tastes, ideas, and even handwriting, we shall find a great resemblance among women and a great diversity among men. Although, as we have seen, man excels woman among the European races, this is not the case in certain inferior races, where the feminine sex is more vigorous and more intelligent than the masculine. The women are equal or superior among certain African tribes—as in Dahomey, where they are the soldiers and have a higher official rank—among some of the hill tribes of India, among the Pueblos of North America, in Kamtchatka according to Meiners, among some Afghan tribes in Java, and among the Morotokos of South America. The Patagonian women, according to De Rochas, are almost as large and as brave as the men, and a woman is chief; and when in an inferior race the man surpasses the woman, his pre-eminence is always less than it is among the superior races. This is shown by different anthropologists to be the case with reference to the length of the radius (Broca), the dimensions of the shoulder-blades (Dr. Livon), and the general stature. The two sexes are of the same size among the Bushmen and the Patagonians (De Rochas). The difference in favor of the man among the Europeans averages eighty-six millimetres according to Quetelet, and twelve centimetres according to M. Topinard (4·68 inches). A similar diversity in differences of cranial capacity is indicated by the measurements of Broca, and by the observations of M. Huschke and Mr. J. B. Davis, that the difference in this respect in favor of the man increases as the race is more elevated. The same rule is applied to the general external aspect by M. Pruner Bey, whose conclusion is supported by his own observations of the Druses and those of M. G. Pouchet among the Arabs of Upper Nubia. We need not go as far as this, for some anthropologists tell us that the difference is less noticeable between Russian than between French men and women.

What we have noticed relative to living inferior tribes is equally observed among ancient inferior races. Some of the peoples of antiquity were governed by women, of whom Semiramis, Dido, Athalia, Cleopatra, Zenobia, etc., are examples. Diodorus speaks of the equality of the sexes among the ancient Scythians. According to the Roman historians, the Teutonic, Cimbrian, and Gallic women fought with as much courage as the men. Among some of the Pelasgian peoples and the Ibero-Ligurians, women decided concerning war and peace. The physical and intellectual predominance of the men was, on the other hand, considerable among the Greeks and Romans. The pre-eminence

of the men of the higher races grows at a rate corresponding with the progress of evolution. According to Broca's investigations, the superiority of the man's cranial capacity is fifty per cent. more among the French in general, and a hundred and twenty-one per cent. more among the Parisians, than it was in the Cro-Magnon race. Very curiously, the cranial capacity of the prehistoric women was greater than that of the women of to-day. It appears demonstrated, says Broca, that the women participating more actively in the labors of the men had at the same time a more considerable cranial capacity than in our days. Zametti, of Sardinia, and Le Bon announce the same view on this point, and Le Bon says that the difference in the average cranial capacity of modern Parisian men and women is nearly double what is observed between the masculine and feminine skulls of Egypt.

Thus the superiority of women appears everywhere among ancient and modern inferior races, but is never observed among superior races, which are, on the contrary, always characterized by the pre-eminence of the man. Whether we regard species or races, we see evolution constantly advancing from the supremacy of the female to that of the male.

The same appears to take place in respect to age. Girls grow faster than boys till they are seventeen, after which the man keeps on growing and the woman remains at a stand-still. So, in the intellectual point, teachers in mixed schools observe that girls hold the first rank till they are twelve years old, and a lower rank afterward. Woman is, therefore, physically, intellectually, and morally, more precocious than man. Buffon believes that this difference bears a relation to the more solid development of the tissues of men; but precocity itself, according to the investigations I have reported to the Société de Biologie, is a character of inferiority—for it is always followed by an arrest of development—observable among all females of animals and of men. As a rule, man differs from woman more at the age of maturity than during youth or old age, in such a manner that the maximum of masculine pre-eminence corresponds with the climax of his evolution.

Whether we consider the organism in general or the several organs separately, we shall find that the differences, null during fetal life and slight at birth, go on increasing till they reach their sum at adult age, then diminish during old age. This is the case in respect to stature, where, according to Quetelet and M. Topinard, the difference of one centimetre at birth grows to one of twelve centimetres at maturity, after which a tendency to return to equality manifests itself; it is so in case of the difference in weight, which increases from three hundred and fifty grammes (or about twelve and one-sixth ounces) at birth to five, eight, or eleven kilogrammes (twelve and a half to twenty-seven pounds), according to different authors, at maturity, and falls off again with advancing age. The heads of boys measure a

centimetre (four tenths of an inch) more at birth than those of girls (Liharzic). The difference increases by reason of the girl's head ceasing to grow much earlier than the man's. The difference in favor of the male in the weight of the brain about triples itself in the course of the first twenty years, and amounts, according to Broca, to seven per cent. between twenty-one and thirty years, to eleven per cent. between thirty-one and forty, then falls to ten per cent. between forty-one and fifty, and to eight per cent. between fifty-one and sixty years. After sixty years the weight diminishes, and the man's brain loses eighty-four grammes (three ounces), and the woman's fifty-nine grammes (about two and a half ounces) from the mean weight it attained at maturity. These anatomical differences bring on intellectual and moral differences that explain why in higher societies the two sexes, after sharing each other's sports in infancy, become separated during the age of maturity, and become again more alike in old age. The same facts are established in regard to the general aspect. Till the time of puberty, says M. Topinard, the skeletons hardly differ appreciably, the features are rather feminine. The man begins to be traceable only at puberty. At about forty-five years the distinctions begin to attenuate, and the sexes end by resembling each other in advanced age, when, however, the characteristics are rather masculine.

The same is the case in respect to the nutritive phenomena, to the amount of carbonic acid produced, to the volume of the lungs, to the quantity of salt in the blood, and to the pulse.

We gather from this review that the female sex surpasses the male in certain points during the first twelve years; then the male gains upon the female and acquires a pre-eminence that increases till the age of maturity, after which it falls off during old age. This pre-eminence is parallel with the progress of evolution, for its maximum corresponds with the apogee of evolution, which, we know, occurs at between forty and fifty years.

The pre-eminence of man over woman is more considerable in the case of large than of small persons. M. Verneau says that the differences in the size of the pelvis of the two sexes vary according to the general stature. The pre-eminence is greater among the inhabitants of the cities than with countrymen, among Parisians than among provincials. Broca assigns a difference of one hundred and fifty cubic centimetres in cranial capacity between French men and women in general, and of two hundred and twenty-one cubic centimetres between Parisians. M. Pruner Bey having remarked that among non-civilized races the women have masculine forms approaching that of a man, adds that the same phenomenon exists, although in a smaller degree, among the "inferior classes" of civilized races. It is easy to observe in our cities how much more the men differ from the women among the richer than among the poorer classes. And it is often the case in the latter classes that the woman is more intelligent than the man who

has been brutalized by manual labor and drink. The advocates of Paris who are accustomed to plead for the workmen have remarked that the women are able to put their cases much better than their husbands, and often say to the latter, "Send me your wife."

The biological considerations we have adduced explain to us why the two sexes tend to diverge from each other as we proceed from the lower to the higher classes. Both sexes among peasants and working-people having nearly the same moral and intellectual faculties, they can sympathize with each other, and have no reason for becoming estranged. It is different among the intelligent classes, where the two sexes, in consequence of the increasing pre-eminence of man, not having the same ideas, the same sentiments, nor the same tastes, can not understand each other, and form separate coteries. Moralists have long taken notice of the separation, which is of force in the family and in the meetings of men and of women, which seem to be increasing from year to year.

According to M. Le Bon's researches, the different social classes should be ranked by their cranial capacity as follows: literary and scientific men, middle-class men (*bourgeois*), nobles, servants, peasants. The separation of which we speak widens as we rise from the peasant to the man of science, passing the servant, the noble, and the middle-class man. It appears, then, like the pre-eminence of man over woman, to be measured proportionately to the cranial capacity and the development of intelligence.

It might be thought that the physical and intellectual inferiority of woman is a consequence of her muscles and brain being less exercised than those of man. This is not correct. As to bodily strength, it readily appears in the circus, where the two sexes receive the same physical education, that the boy is always more vigorous than the girl, and constantly maintains his superiority over her. Some difficult feats which the men perform regularly are forbidden to the women. The view that the intellectual superiority of man and inferiority of woman are due to differences in education is likewise not just. In former ages, when the mass of the people were groping in ignorance, neither sex was better instructed than the other; and now, in the France of to-day, there are still six hundred thousand children of both sexes who never set foot in a school, and receive absolutely no education. We can, then, say with Professor Bischoff, of Munich, that "women have suffered no other hindrances to the exercise and evolution of their brains and their intellect than those that are derived from their constitution and their faculties of development." The pretense that woman never receives the same education as man is, moreover, false. Female pupils receive precisely the same musical instruction at the music-schools as male pupils. How comes it then that, although there are incomparably more women than men following music as a profession, women furnish good performers but no composers? The same

observation is applicable to painting and the culinary art. Why is it that, while all the men who devote themselves to the latter art become good cooks, there are among the thousands of women who exercise it as a profession so few of the first quality?

We have already seen that in mixed schools, where children of both sexes receive precisely the same education till they are fifteen years old, the girls at first are ahead by virtue of their natural precocity, but, on passing twelve years, fall behind the boys. The arrest in the development that takes place in woman at about this time is the real cause of the growing pre-eminence of man, who continues to develop till an advanced age. If the girl begins thus to fall behind the boy at a certain point after having enjoyed the same training, it must be that her inferiority is real, and can not be ascribed to a difference in education that does not exist.

Thus equality in the instruction of individuals of the two sexes, the equal working of the brain, instead of re-establishing equality between them, increases the pre-eminence of the males, and this explains why woman is less perfectible than man. The equality of the sexes dreamed of by the philosophers is, then, not near being realized. On the contrary, that equality which existed among the primitive races, and still exists among some savages, is tending more and more to disappear with the progress of civilization. The pre-eminence of man over woman, which is a product of the evolution of individuals and races, is rather increased by instruction, the effect of which, far from re-establishing the equality of the sexes, is to assure definitively the supremacy of man.

It would be interesting to investigate the effect of the environment on the differences between the sexes. I am inclined to believe that the differences diminish as we go south. In Italy, for example, according to statistics covering a period of fourteen years, published by the Minister of Agriculture, the excess in the height of men over women falls from forty-two millimetres (1·63 inch) in the northern provinces to twenty-nine millimetres (1·13 inch) in the southern provinces. According to Broca, women are more nearly of the same size as men in mountainous than in flat countries. To summarize our argument, the pre-eminence of the female sex over the male, occurring only in certain inferior species and races, and in children of the superior races, marks an inferior degree of evolution. The same may be said of equality of the sexes, which is observable only among individuals little advanced in evolution: inferior races and species, youth, aged persons, and the lower classes. On the contrary, the pre-eminence of the male over the female represents a superior phase of evolution, for it characterizes superior species and races, the adult age, and the higher classes. In the moral as in the physical point of view, evolution appears to me, then, to advance from the pre-eminence of the female sex to that of the male sex; equality of the sexes would thus be a stage in the natural transition between the two opposite phases of evolution.

A HALF-CENTURY OF SCIENCE.*

By Sir JOHN LUBBOCK.

II.

IN astronomy, the discovery in 1845 of the planet Neptune, made independently and almost simultaneously by Adams and by Le Verrier, was certainly one of the very greatest triumphs of mathematical genius. Of the minor planets, four only were known in 1831, while the number now on the roll amounts to 220. Many astronomers believe in the existence of an intra-Mercurial planet or planets, but this is still an open question. The solar system has also been enriched by the discovery of an inner ring to Saturn, of satellites to Mars, and of additional satellites to Saturn, Uranus, and Neptune.

The most unexpected progress, however, in our astronomical knowledge, during the past half-century, has been due to spectrum analysis. The dark lines in the spectrum were first seen by Wollaston, who noticed a few of them; but they were independently discovered by Fraunhofer, after whom they are justly named, and who, in 1814, mapped no fewer than 576. The first steps in "spectrum analysis," properly so called, were made by Sir J. Herschel, Fox Talbot, and by Wheatstone, in a paper read before this Association in 1835. The latter showed that the spectrum emitted by the incandescent vapor of metals was formed of bright lines, and that these lines, while, as he then supposed, constant for each metal, differed for different metals. "We have here," he said, "a mode of discriminating metallic bodies more readily than that of chemical examination, and which may hereafter be employed for useful purposes." Nay, not only can bodies thus be more readily discriminated, but, as we now know, the presence of extremely minute portions can be detected, the $\frac{1}{8000000}$ of a grain being in some cases easily perceptible.

It is also easy to see that the presence of any new simple substance might be detected, and in this manner already several new elements have been discovered, as I shall mention when we come to chemistry.

But spectrum analysis has led to even grander and more unexpected triumphs. Fraunhofer himself noticed the coincidence between the double dark line D of the solar spectrum and a double line which he observed in the spectra of ordinary flames, while Stokes pointed out to Sir W. Thomson, who taught it in his lectures, that in both cases these lines were due to the presence of sodium. To Kirchhoff and Bunsen, however, is due the independent conception and the credit of having first systematically investigated the relation which exists between

* Presidential address before the York Meeting of the British Association for the Advancement of Science.

Fraunhofer's lines and the bright lines in the spectra of incandescent metals. In order to get some fixed measure by which they might determine and record the lines characterizing any given substance, it occurred to them that they might use for comparison the spectrum of the sun. They accordingly arranged their spectroscope so that one half of the slit was lighted by the sun, and the other by the luminous gases they proposed to examine. It immediately struck them that the bright lines in the one corresponded with the dark lines in the other—the bright line of sodium, for instance, with the line or rather lines D in the sun's spectrum. The conclusion was obvious. There was sodium in the sun! It must indeed have been a glorious moment when that thought flashed across them, and even by itself well worth all their labor.

But why is the bright line of a sodium-flame represented by a black one in the spectrum of the sun! To Angstrom is due the theory that a vapor or gas can absorb luminous rays of the same refrangibility only which it emits when highly heated; while Balfour Stewart independently discovered the same law with reference to radiant heat.

This is the basis of Kirchhoff's theory of the origin of Fraunhofer's lines. In the atmosphere of the sun the vapors of various metals are present, each of which would give its characteristic lines, but within this atmospheric envelope is the still more intensely heated nucleus of the sun, which emits a brilliant continuous spectrum, containing rays of all degrees of refrangibility. When the light of this intensely-heated nucleus is transmitted through the surrounding atmosphere, the bright lines which would be produced by this atmosphere are seen as dark ones.

Kirchhoff and Bunsen thus proved the existence in the sun of hydrogen, sodium, magnesium, calcium, iron, nickel, chromium, manganese, titanium, and cobalt; since which Angstrom, Thalén, and Lockyer have considerably increased the list. But it is not merely the chemistry of the heavenly bodies on which light is thrown by the spectroscope; their physical structure and evolutional history are also illuminated by this wonderful instrument of research. It used to be supposed that the sun was a dark body enveloped in a luminous atmosphere. The reverse now appears to be the truth. The body of the sun, or photosphere, is intensely brilliant; round it lies the solar atmosphere of comparatively cool gases, which cause the dark lines in the spectrum; thirdly, a chromosphere—a sphere principally of hydrogen, jets of which are said sometimes to reach to a height of 100,000 miles or more, into the outer coating or corona, the nature of which is still very doubtful.

Formerly the red flames which represent the higher regions of the chromosphere could be seen only on the rare occasions of a total solar eclipse. Janssen and Lockyer, by the application of the spectroscope, have enabled us to study this region of the sun at all times. It is,

moreover, obvious that the powerful engine of investigation afforded us by the spectroscope is by no means confined to the substances which form part of our system. The incandescent body can thus be examined, no matter how great its distance, so long only as the light is strong enough. That this method was theoretically applicable to the light of the stars was indeed obvious, but the practical difficulties were very great. Sirius, the brightest of all, is, in round numbers, a hundred millions of millions of miles from us ; and, though as big as sixty of our suns, his light when it reaches us, after a journey of sixteen years, is at most one two-thousand-millionth part as bright. Nevertheless, as long ago as 1815 Fraunhofer recognized the fixed lines in the light of four of the stars, and in 1863 Miller and Huggins in our own country, and Rutherfurd in America, succeeded in determining the dark lines in the spectrum of some of the brighter stars, thus showing that these beautiful and mysterious lights contain many of the material substances with which we are familiar. In Aldebaran, for instance, we may infer the presence of hydrogen, sodium, magnesium, iron, calcium, tellurium, antimony, bismuth, and mercury ; some of which are not yet known to occur in the sun. As might have been expected, the composition of the stars is not uniform, and it would appear that they may be arranged in a few well-marked classes, indicating differences of temperature, or, in other words, of age. Some recent photographic spectra of stars obtained by Huggins go very far to justify this view. Thus we can make the stars teach us their own composition with light which started from its source before we were born—light older than our Association itself.

Until 1864, the true nature of the unresolved nebulæ was a matter of doubt. In that year, however, Huggins turned his spectroscope on to a nebula, and made the unexpected discovery that the spectra of some of these bodies are discontinuous—that is to say, consist of bright lines only, indicating that, "in place of an incandescent solid or liquid body, we must probably regard these objects, or at least their photo-surfaces, as enormous masses of luminous gas or vapor. For it is from matter in a gaseous state only that such light as that of the nebulæ is known to be emitted." So far as observation has yet gone, nebulæ may be divided into two classes : some giving a continuous spectrum, others one consisting of bright lines. These latter all appear to give essentially the same spectrum, consisting of a few bright lines. Two of them, in Mr. Huggins's opinion, indicate the presence of hydrogen : one of them agrees in position with a line characteristic of nitrogen.

But spectrum analysis has even more than this to tell us. The old methods of observation could determine the movements of the stars so far only as they were transverse to us ; they afforded no means of measuring motion either directly toward or away from us. Now, Döppler suggested in 1841 that the colors of the stars would assist us in this respect, because they would be affected by their motion to and

from the earth, just as a steam-whistle is raised or lowered as it approaches or recedes from us. Every one has observed that if a train whistles as it passes us, the sound appears to alter at the moment the engine goes by. This arises, of course, not from any change in the whistle itself, but because the number of vibrations which reach the ear in a given time are increased by the speed of the train as it approaches, and diminished as it recedes. So, like the sound, the color would be affected by such a movement; but Döppler's method was practically inapplicable, because the amount of effect on the color would be utterly insensible; and even if it were otherwise, the method could not be applied, because, as we did not know the true color of the stars, we have no datum-line by which to measure.

A change of refrangibility of light, however, does occur in consequence of relative motion, and Huggins successfully applied the spectroscope to solve the problem. He took in the first place the spectroscope of Sirius, and chose a line known as F, which is due to hydrogen. Now, if Sirius was motionless, or rather if it retained a constant distance from the earth, the line F would occupy exactly the same position in the spectrum of Sirius as in that of the sun. On the contrary, if Sirius were approaching or receding from us, this line would be slightly shifted either toward the blue or red end of the spectrum. He found that the line had moved very slightly toward the red, indicating that the distance between us and Sirius is increasing at the rate of about twenty miles a second. So also Betelgeux, Rigel, Castor, and Regulus are increasing their distance; while, on the contrary, that of others, as for instance of Vega, Arcturus, and Pollux, is diminishing. The results obtained by Huggins on about twenty stars have since been confirmed and extended by Mr. Christie, now Astronomer-Royal in succession to Sir G. Airy, who has long occupied the post with so much honor to himself and advantage to science.

To examine the spectrum of a shooting-star would seem even more difficult; yet Alexander Herschel has succeeded in doing so, and finds that their nuclei are incandescent solid bodies; he has recognized the lines of potassium, sodium, lithium, and other substances, and considers that the shooting-stars are bodies similar in character and composition to the stony masses which sometimes reach the earth as aërolites.

Some light has also been thrown upon those mysterious visitants, the comets. The researches of Professor Newton on the periods of meteoroids led to the remarkable discovery by Schiaparelli of the identity of the orbits of some meteor-swarms with those of some comets. The similarity of orbits is too striking to be the result of chance, and shows a true cosmical relation between the bodies. Comets, in fact, are in some cases at any rate groups of meteoric stones. From the spectra of the small comets of 1866 and 1868, Huggins showed that part of their light is emitted by themselves, and reveals the presence

of carbon in some form. A photographic spectrum of the comet recently visible, obtained by the same observer, is considered by him to prove that nitrogen, probably in combination with carbon, is also present.

No element has yet been found in any meteorite, which was not previously known as existing in the earth, but the phenomena which they exhibit indicate that they must have been formed under conditions very different from those which prevail on the earth's surface. I may mention, for instance, the peculiar form of crystallized silica, called by Maskelyne, asmanite; and the whole class of meteorites, consisting of iron generally alloyed with nickel, which Daubrée terms holosiderites. The interesting discovery, however, by Nordenskjöld, in 1870, at Ovifak, of a number of blocks of iron alloyed with nickel and cobalt, in connection with basalts containing disseminated iron, has, in the words of Judd, "afforded a very important link, placing the terrestrial and extra-terrestrial rocks in closer relations with one another."

We have as yet no sufficient evidence to justify a conclusion as to whether any substances exist in the heavenly bodies which do not occur in our earth, though there are many lines which can not yet be satisfactorily referred to any terrestrial element. On the other hand, some substances which occur on our earth have not yet been detected in the sun's atmosphere. Such discoveries as these seemed, not long ago, entirely beyond our hopes. M. Comte, indeed, in his "Cours de Philosophie Positive," as recently as 1842, laid it down as an axiom regarding the heavenly bodies, that "nous concevons la possibilité de déterminer leurs formes, leurs distances, leurs grandeurs et leurs mouvements, tandis que nous ne saurions jamais étudier par aucun moyen leur composition chimique ou leur structure minéralogique." Yet within a few years this supposed impossibility has been actually accomplished, showing how unsafe it is to limit the possibilities of science.

It is hardly necessary to point out that, while the spectrum has taught us so much, we have still even more to learn. Why should some substances give few, and others many, lines? Why should the same substance give different lines at different temperatures? What are the relations between the lines and the physical or chemical properties? We may certainly look for much new knowledge of the hidden actions of atoms and molecules from future researches with the spectroscope. It may even, perhaps, teach us to modify our views of the so-called simple substances. Prout long ago, struck by the remarkable fact that nearly all atomic weights are simple multiples of the atomic weight of hydrogen, suggested that hydrogen must be the primordial substance. Brodie's researches also naturally fell in with the supposition that the so-called simple substances are in reality complex, and that their constituents occur separately in the hottest regions

of the solar atmosphere. Lockyer considers that his researches lend great probability to this view. The whole subject is one of intense interest, and we may rejoice that it is occupying the attention, not only of such men as Abney, Dewar, Hartley, Liveing, Roscoe, and Schuster in our own country, but also of many foreign observers.

When geology so greatly extended our ideas of past time, the continued heat of the sun became a question of greater interest than ever. Helmholtz has shown that, while adopting the nebular hypothesis, we need not assume that the nebulous matter was originally incandescent; but that its present high temperature may be, and probably is, mainly due to gravitation between its parts. It follows that the potential energy of the sun is far from exhausted, and that with continued shrinking it will continue to give out light and heat, with little, if any, diminution for several million years.

Like the sand of the sea, the stars of heaven have ever been used as effective symbols of number, and the improvements in our methods of observation have added fresh force to our original impressions. We now know that our earth is but a fraction of one out of at least 75,000,000 worlds. But this is not all. In addition to the luminous heavenly bodies, we can not doubt that there are countless others, invisible to us from their greater distance, smaller size, or feebler light; indeed, we know that there are many dark bodies which now emit no light, or comparatively little. Thus, in the case of Procyon, the existence of an invisible body is proved by the movement of the visible star. Again, I may refer to the curious phenomena presented by Algol, a bright star in the head of Medusa. This star shines without change for two days and thirteen hours; then, in three hours and a half, dwindles from a star of the second to one of the fourth magnitude; and then, in another three and a half hours, reassumes its original brilliancy. These changes seem certainly to indicate the presence of an opaque body, which intercepts at regular intervals a part of the light emitted by Algol.

Thus the floor of heaven is not only "thick inlaid with patines of bright gold," but studded also with extinct stars; once, probably, as brilliant as our own sun, but now dead and cold, as Helmholtz tells us that our sun itself will be, some seventeen million years hence.

The connection of astronomy with the history of our planet has been a subject of speculation and research during a great part of the half-century of our existence. Sir Charles Lyell devoted some of the opening chapters of his great work to the subject. Haughton has brought his very original powers to bear on the subject of secular changes in climate, and Croll's contributions to the same subject are of great interest. Last, but not least, I must not omit to make mention of the series of massive memoirs (I am happy to say, not yet nearly terminated) by George Darwin on tidal friction, and the influence of tidal action on the evolution of the solar system. I may, per-

haps, just mention, as regards telescopes, that the largest reflector, in 1830, was Sir W. Herschel's, of four feet; the largest at present being Lord Rosse's, of six feet; as regards refractors, the largest then had a diameter of eleven and a quarter inches, while your fellow-townsman, Cooke, carried the size to twenty-five inches, and Mr. Grubb, of Dublin, has just successfully completed one of twenty-seven inches for the Observatory of Vienna. It is remarkable that the two largest telescopes in the world should both be Irish.

The general result of astronomical researches has been thus eloquently summed up by Proctor: "The sidereal system is altogether more complicated and more varied in structure than has hitherto been supposed; in the same region of the stellar depths coexist stars of many orders of real magnitude; all orders of nebulæ, gaseous or stellar, planetary, ring-formed, elliptical, and spiral, exist within the limits of the galaxy; and, lastly, the whole system is alive with movements, the laws of which may one day be recognized, though at present they appear too complex to be understood."

We can, I think, scarcely claim the establishment of the undulatory theory of light as falling within the last fifty years; for though Brewster, in his "Report on Optics," published in our first volume, treats the question as open, and expresses himself still unconvinced, he was, I believe, almost alone in his preference for the emission theory. The phenomena of interference, in fact, left hardly any—if any—room for doubt, and the subject was finally set at rest by Foucault's celebrated experiments in 1850. According to the undulatory theory, the velocity of light ought to be greater in air than in water, while if the emission theory were correct the reverse would be the case. The velocity of light—186,000 miles in a second—is, however, so great that, to determine its rate in air, as compared with that in water, might seem almost hopeless. The velocity in air was, nevertheless, determined by Fizeau in 1849, by means of a rapidly revolving wheel. In the following year Foucault, by means of a revolving mirror, demonstrated that the velocity of light is greater in air than in water—thus completing the evidence in favor of the undulatory theory of light.

The idea is now gaining ground that, as maintained by Clerk Maxwell, light itself is an electro-magnetic disturbance, the luminiferous ether being the vehicle of both light and electricity.

Wünsch, as long ago as 1792, had clearly shown that the three primary colors were red, green, and violet; but his results attracted little notice, and the general view used to be that there were seven principal colors—red, orange, yellow, green, blue, indigo, and violet; four of which—namely, orange, green, indigo, and violet—were considered to arise from mixtures of the other three. Red, yellow, and blue were therefore called the primary colors, and it was supposed that in order to produce white light these three colors must always be present.

Helmholtz, however, again showed, in 1852, that a color to our unaided eyes identical with white was produced by combining yellow with indigo. At that time yellow was considered to be a simple color, and this, therefore, was regarded as an exception to the general rule, that a combination of three simple colors is required to produce white. Again, it was, and indeed still is, the general impression that a combination of blue and yellow makes green. This, however, is entirely a mistake. Of course, we all know that yellow paint and blue paint make green paint; but this results from absorption of light by the semi-transparent solid particles of the pigments, and is not a mere mixture of the colors proceeding unaltered from the yellow and the blue particles; moreover, as can easily be shown by two sheets of colored paper and a piece of window-glass, blue and yellow light, when combined, do not give a trace of green, but if pure would produce the effect of white. Green, therefore, is after all not produced by a mixture of blue and yellow. On the other hand, Clerk Maxwell proved in 1860 that yellow could be produced by a mixture of red and green, which put an end to the pretension of yellow to be considered a primary element of color. From these and other considerations it would seem, therefore, that the three primary colors—if such an expression be retained—are red, green, and violet.

The existence of rays beyond the violet, though almost invisible to our eyes, had long been demonstrated by their chemical action. Stokes, however, showed in 1852 that their existence might be proved in another manner, for that there are certain substances which, when excited by them, emit light visible to our eyes. To this phenomenon he gave the name of fluorescence. At the other end of the spectrum Abney has recently succeeded in photographing a large number of lines in the infra-red portion, the existence of which was first proved by Sir William Herschel.

From the rarity, and in many cases the entire absence, of reference to blue, in ancient literature, Geiger—adopting and extending a suggestion first thrown out by Mr. Gladstone—has maintained that, even as recently as the time of Homer, our ancestors were blue-blind. Though for my part I am unable to adopt this view, it is certainly very remarkable that neither the "Rigveda," which consists almost entirely of hymns to heaven, nor the "Zendavesta," the Bible of the Parsees or fire-worshipers, nor the Old Testament, nor the Homeric poems, ever allude to the sky as blue.

On the other hand, from the dawn of poetry, the splendors of the morning and evening skies have excited the admiration of mankind. As Ruskin says, in language almost as brilliant as the sky itself, the whole heaven, "from the zenith to the horizon, becomes one molten, mantling sea of color and fire; every black bar turns into massy gold, every ripple and wave into unsullied, shadowless crimson, and purple, and scarlet, and colors for which there are no words in language, and

no ideas in the mind—things which can only be conceived while they are visible; the intense hollow blue of the upper sky melting through it all, showing here deep, and pure, and lightness; there, modulated by the filmy, formless body of the transparent vapor, till it is lost imperceptibly in its crimson and gold."

But what is the explanation of these gorgeous colors? why is the sky blue? and why are the sunrise and sunset crimson and gold? It may be said that the air is blue; but, if so, how can the clouds assume their varied tints? Brücke showed that very minute particles suspended in water are blue by reflected light. Tyndall has taught us that the blue of the sky is due to the reflection of the blue rays by the minute particles floating in the atmosphere. Now, if from the white light of the sun the blue rays are thus selected, those which are transmitted will be yellow, orange, and red. Where the distance is short the transmitted light will appear yellowish. But as the sun sinks toward the horizon the atmospheric distance increases, and consequently the number of the scattering particles. They weaken in succession the violet, the indigo, the blue, and even disturb the proportions of green. The transmitted light under such circumstances must pass from yellow through orange to red, and thus, while we at noon are admiring the deep blue of the sky, the same rays, robbed of their blue, are elsewhere lighting up the evening sky with all the glories of sunset.

Another remarkable triumph of the last half-century has been the discovery of photography. At the commencement of the century Wedgwood and Davy observed the effect produced by throwing the images of objects on paper or leather prepared with nitrate of silver, but no means were known by which such images could be fixed. This was first effected by Niepce, but his processes were open to objections which prevented them from coming into general use, and it was not till 1839 that Daguerre invented the process which was justly named after him. Very soon a further improvement was effected by our countryman Talbot. He not only fixed his "Talbotypes" on paper—in itself a great convenience—but, by obtaining a negative, rendered it possible to take off any number of positive, or natural, copies from one original picture. This process is the foundation of all the methods now in use; perhaps the greatest improvements having been the use of glass plates, first proposed by Sir John Herschel; of collodion, suggested by Le Grey, and practically used by Archer; and, more lately, of gelatine, the foundation of the sensitive film now growing into general use in the ordinary dry-plate process. Not only have a great variety of other beautiful processes been invented, but the delicacy of the sensitive film has been immensely increased, with the advantage, among others, of diminishing greatly the time necessary for obtaining a picture, so that even an express-train going at full speed can now be taken. Indeed, with full sunlight, $\frac{1}{600}$ of a second is

enough, and in photographing the sun itself $\frac{1}{60000}$ of a second is sufficient.

We owe to Wheatstone the conception that the idea of solidity is derived from the combination of two pictures of the same object in slightly different perspective. This he proved in 1833 by drawing two outlines of some geometrical figure or other simple object, as they would appear to either eye respectively, and then placing them so that they might be seen, one by each eye. The "stereoscope," thus produced, has been greatly popularized by photography.

For two thousand years the art of lighting had made little if any progress. Until the close of the last century, for instance, our lighthouses contained mere fires of wood or coal, though the construction had vastly improved. The Eddystone Lighthouse, for instance, was built by Smeaton in 1759; but for forty years its light consisted in a row of tallow candles stuck in a hoop. The Argand lamp was the first great improvement, followed by gas, and in 1863 by the electric light.

Just as light was long supposed to be due to the emission of material particles, so heat was regarded as a material, though ethereal, substance, which was added to bodies when their temperature was raised.

Davy's celebrated experiment of melting two pieces of ice by rubbing them against one another in the exhausted receiver of an air-pump, had convinced him that the cause of heat was the motion of the invisible particles of bodies, as had been long before suggested by Newton, Boyle, and Hooke. Rumford and Young also advocated the same view. Nevertheless, the general opinion, even until the middle of the present century, was that heat was due to the presence of a subtile fluid known as "caloric," a theory which is now entirely abandoned.

Melloni, by the use of the electric pile, vastly increased our knowledge of the phenomena of radiant heat. His researches were confined to the solid and liquid forms of matter. Tyndall studied the gases in this respect, showing that differences greater than those established by Melloni existed between gases and vapors, both as regards the absorption and radiation of heat. He proved, moreover, that the aqueous vapor of our atmosphere, by checking terrestrial radiation, augments the earth's temperature, and he considers that the existence of tropical vegetation—the remains of which now constitute our coal-beds—may have been due to the heat retained by the vapors which at that period were diffused in the earth's atmosphere. Indeed, but for the vapor in our atmosphere, a single night would suffice to destroy the whole vegetation of the temperate regions.

Inspired by a contemplation of Graham Bell's ingenious experiments with intermittent beams on solid bodies, Tyndall took a new and original departure; and regarding the sounds as due to changes

of temperature, he concluded that the same method would prove applicable to gases. He thus found himself in possession of a new and independent method of procedure. It need, perhaps, be hardly added that, when submitted to this new test, his former conclusions on the interaction of heat and gaseous matter stood their ground.

The determination of the mechanical equivalent of heat is mainly due to the researches of Mayer and Joule. Mayer, in 1842, pointed out the mechanical equivalent of heat as a fundamental datum to be determined by experiment. Taking the heat produced by the condensation of air as the equivalent of the work done in compressing the air, he obtained a numerical value of the mechanical equivalent of heat. There was, however, in these experiments, one weak point. The matter operated on did not go through a cycle of changes. He assumed that the production of heat was the only effect of the work done in compressing the air. Joule had the merit of being the first to meet this possible source of error. He ascertained that a weight of one pound would have to fall 772 feet in order to raise the temperature of one pound of water by 1° Fahr. Hirn subsequently attacked the problem from the other side, and showed that if all the heat passing through a steam-engine was turned into work, for every degree Fahr. added to the temperature of a pound of water, enough work could be done to raise a weight of one pound to a height of 772 feet. The general result is that, though we can not create energy, we may help ourselves to any extent from the great storehouse of nature. Wind and water, the coal-bed and the forest, afford man an inexhaustible supply of available energy.

It used to be considered that there was an absolute break between the different states of matter. The continuity of the gaseous, liquid, and solid conditions was first demonstrated by Andrews in 1862. Oxygen and nitrogen have been liquefied independently and at the same time by Cailletet and Raoul Pictet. Cailletet also succeeded in liquefying air, and soon afterward hydrogen was liquefied by Pictet under a pressure of 650 atmospheres, and a cold of 170° Cent. below zero. It even became partly solidified, and he assures us that it fell on the floor with "the shrill noise of metallic hail." Thus, then, it was shown experimentally that there are no such things as absolutely permanent gases.

The kinetic theory of gases, now generally accepted, refers the elasticity of gases to a motion of translation of their molecules, and we are assured that, in the case of hydrogen at a temperature of 60° Fahr., they move at an average rate of 6,225 feet in a second; while, as regards their size, Loschmidt, who has since been confirmed by Stoney and Sir W. Thomson, calculates that each is at most $\frac{1}{50000000}$ of an inch in diameter.

We can not, it would seem, at present hope for any increase of our knowledge of atoms by any improvement in the microscope. With

our present instruments we can perceive lines ruled on glass of $\frac{1}{50000}$ of an inch apart. But, owing to the properties of light itself, the fringes due to interference begin to produce confusion at distances of $\frac{1}{74000}$, and in the brightest part of the spectrum at little more than $\frac{1}{90000}$ they would make the obscurity more or less complete. If, indeed, we could use the blue rays by themselves, their waves being much shorter, the limit of possible visibility might be extended to $\frac{1}{120000}$; and, as Helmholtz has suggested, this perhaps accounts for Stinde having actually been able to obtain a photographic image of lines only $\frac{1}{100000}$ of an inch apart. It would seem, then, that, owing to the physical characters of light, we can, as Sorby has pointed out, scarcely hope for any great improvement so far as the mere visibility of structure is concerned, though in other respects, no doubt, much may be hoped for. At the same time, Dallinger and Royston Pigott have shown that, so far as the mere presence of simple objects is concerned, bodies of even smaller dimensions can be perceived.

Sorby is of opinion that in a length of $\frac{1}{80000}$ of an inch there would probably be from 500 to 2,000 molecules—500, for instance, in albumen and 2,000 in water. Even, then, if we could construct microscopes far more powerful than any we now possess, they would not enable us to obtain by direct vision any idea of the ultimate molecules of matter. Sorby calculates that the smallest sphere of organic matter which could be clearly defined with our most powerful microscopes would contain many millions of molecules of albumen and water, and it follows that there may be an almost infinite number of structural characters in organic tissues, which we can at present foresee no mode of examining.

The science of meteorology has made great progress; the weather, which was formerly treated as a local phenomenon, being now shown to form part of a vast system of mutually dependent cyclonic and anti-cyclonic movements. The storm-signals issued at our ports are very valuable to sailors, while the small weather-maps, for which we are mainly indebted to Francis Galton, and the forecasts, which any one can obtain on application, either personally or by telegraph, at the Meteorological Office, are also of increasing utility.

Electricity, in the year 1831, may be considered to have just been ripe for its adaptation to practical purposes; it was but a few years previously, in 1819, that Oersted had discovered the deflective action of the current on the magnetic needle, that Ampère had laid the foundation of electro-dynamics, that Schweigger had devised the electric coil or multiplier, and that Sturgeon had constructed the first electro-magnet. It was in 1831 that Faraday, the prince of pure experimentalists, announced his discoveries of voltaic induction and magneto-electricity, which, with the other three discoveries, constitute the principles of nearly all the telegraph instruments now in use; and in

1834 our knowledge of the nature of the electric current had been much advanced by the interesting experiment of Sir Charles Wheatstone, proving the velocity of the current in a metallic conductor to approach that of the wave of light.

Practical applications of these discoveries were not long in coming to the fore, and the first telegraph-line on the Great Western Railway, from Paddington to West Drayton, was set up in 1838. In America, Morse is said to have commenced to develop his recording instrument between the years 1832 and 1837, while Steinheil, in Germany, during the same period, was engaged upon his somewhat super-refined ink-recorder, using for the first time the earth for completing the return circuit; whereas in this country Cooke and Wheatstone, by adopting the more simple device of the double-needle instrument, were the first to make the electric telegraph a practical institution. Contemporaneously with, or immediately succeeding these pioneers, we find in this country Alexander Bain, Breguet in France, Schilling in Russia, and Werner Siemens in Germany, the latter having first, in 1847, among others, made use of gutta-percha as an insulating medium for electric conductors, and thus cleared the way for subterranean and submarine telegraphy. Four years later, in 1851, submarine telegraphy became an accomplished fact through the successful establishment of telegraphic communication between Dover and Calais. Submarine lines followed in rapid succession, crossing the English Channel and the German Ocean, threading their way through the Mediterranean, Black, and Red Seas, until in 1866, after two abortive attempts, telegraphic communication was successfully established between the Old and New Worlds, beneath the Atlantic Ocean.

In connection with this great enterprise, and with many investigations and suggestions of a highly scientific and important character, the name of Sir William Thomson will ever be remembered. The ingenuity displayed in perfecting the means of transmitting intelligence through metallic conductors, with the utmost dispatch and certainty as regards the record obtained, between two points hundreds and even thousands of miles apart, is truly surprising. The instruments devised by Morse, Siemens, and Hughes have also proved most useful.

Duplex and quadruplex telegraphy, one of the most striking achievements of modern telegraphy, the result of the labors of several inventors, should not be passed over in silence. It not only serves for the simultaneous communication of telegraphic intelligence in both directions, but renders it possible for four instruments to be worked irrespectively of one another, through one and the same wire connecting to distant places.

Another more recent and perhaps still more wonderful achievement in modern telegraphy is the invention of the telephone and microphone, by means of which the human voice is transmitted through the electric conductor, by mechanism that imposes through its extreme sim-

plicity. In this connection the names of Reiss, Graham Bell, Edison, and Hughes, are those chiefly deserving to be recorded.

While electricity has thus furnished us with the means of flashing our thoughts by record or by voice from place to place, its use is now gradually extending for the achievement of such quantitative effects as the production of light, the transmission of mechanical power, and the precipitation of metals. The principle involved in the magneto-electric and dynamo-electric machines, by which these effects are accomplished, may be traced to Faraday's discovery in 1831 of the induced current, but their realization to the labors of Holmes, Siemens, Pacinotti, Gramme, and others. In the electric light, gas-lighting has found a formidable competitor, which appears destined to take its place in public illumination, and in lighting large halls, works, etc., for which purposes it combines brilliancy and freedom from obnoxious products of combustion, with comparative cheapness. The electric light seems also to threaten, when subdivided in the manner recently devised by Edison, Swan, and others, to make inroads into our dwelling-houses.

By the electric transmission of power we may hope some day to utilize at a distance such natural sources of energy as the Falls of Niagara, and to work our cranes, lifts, and machinery of every description by means of sources of power arranged at convenient centers. To these applications the brothers Siemens have more recently added the propulsion of trains by currents passing through the rails, the fusion in considerable quantities of highly refractory substances, and the use of electric centers of light in horticulture as proposed by Werner and William Siemens. By an essential improvement by Faure of the Planté secondary battery, the problem of storing electrical energy appears to have received a practical solution, the real importance of which is clearly proved by Sir W. Thomson's recent investigation of the subject. It would be difficult to assign the limits to which this development of electrical energy may not be rendered serviceable for the purposes of man.

As regards mathematics, I have felt that it would be impossible for me, even with the kindest help, to write anything myself. Mr. Spottiswoode, however, has been so good as to supply me with the following memorandum :

In a complete survey of the progress of science during the half-century which has intervened between our first and our present meeting, the part played by mathematics would form no insignificant feature. To those, indeed, who are outside its enchanted circle it is difficult to realize the intense intellectual energy which actuates its devotees, or the wide expanse over which that energy ranges. Some measure, however, of its progress may perhaps be formed by considering, in one or two cases, from what simple principles some of the great recent developments have taken their origin.

Consider, for instance, what is known as the principle of signs. In geometry we are concerned with quantities such as lines and angles; and in the old systems a proposition was proved with reference to a particular figure. This figure might, it is true, be drawn in any manner within certain ranges of limitation; but if the limits were exceeded, a new proof, and often a new enunciation, became necessary. Gradually, however, it came to be perceived (e. g., by Carnot, in his "Géometrie de Position") that some propositions were true even when the quantities were reversed in direction. Hence followed a recognition of the principle (of signs) that every line should be regarded as a directed line, and every angle as measured in a definite direction. By means of this simple consideration, geometry has acquired a power similar to that of algebra, viz., of changing the signs of the quantities and transposing their positions, so as at once, and without fresh demonstration, to give rise to new propositions.

To take another instance. The properties of triangles, as established by Euclid, have always been considered as legitimate elements of proof; so that, when in any figure two triangles occur, their relations may be used as steps in a demonstration. But, within the period of which I am speaking, other general geometrical relations, e. g., those of a pencil of rays, or of their intersection with a straight line, have been recognized as serving a similar purpose. With what extensive results this generalization has been attended, the "Géometrie Supérieure" of the late M. Chasles, and all the superstructure built on Anharmonic Ratio as a foundation, will be sufficient evidence.

Once more, the algebraical expression for a line or a plane involves two sets of quantities, the one relating to the position of any point in the line or plane, and the other relating to the position of the line or plane in space. The former set alone were originally considered variable, the latter constant. But as soon as it was seen that either set might at pleasure be regarded as variable, there was opened out to mathematicians the whole field of duality within geometry proper, and the theory of correlative figures which is destined to occupy a prominent position in the domain of mathematics.

Not unconnected with this is the marvelous extension which the transformation of geometrical figures has received very largely from Cremona and the Italian school, and which in the hands of our countrymen Hirst and the late Professor Clifford has already brought forth such abundant fruit. In this, it may be added, there lay—dormant, it is true, and long unnoticed—the principle whereby circular may be converted into rectilinear motion, and *vice versa*—a problem which, until the time of Peaucillier, seemed so far from solution, that one of the greatest mathematicians of the day thought that he had proved its entire impossibility. In the hands of Sylvester, of Kempe, and others, this principle has been developed into a general theory of link-work, on which the last word has not yet been said.

If time permitted, I might point out how the study of particular geometric figures, such as curves and surfaces, has been in many instances replaced by that of systems of figures infinite in number, and, indeed, of various degrees of infinitude. Such, for instance, are Plücker's complexes and congruencies. I might describe also how Riemann taught us that surfaces need not present simple extension without thickness, but that, without losing their essential geometric character, they may consist of manifold sheets; and that our conception of space, and our power of interpreting otherwise perplexing algebraical expressions, become immensely enlarged.

Other generalizations might be mentioned, such as the principle of continuity, the use of imaginary quantities, the extension of the number of the dimensions of space, the recognition of systems in which the axioms of Euclid have no place. But as these were discussed in a recent address, I need not now do more than remind you that the germs of the great calculus of quaternions were first announced by their author, the late Sir W. R. Hamilton, at one of our meetings.

Passing from geometry proper to the other great branch of mathematical machinery, viz., algebra, it is not too much to say that within the period now in review there has grown up a modern algebra, which to our founders would have appeared like a confused dream, and whose very language and terminology would be as an unknown tongue.

Into this subject I do not propose to lead you far. But, as the progress which has been made in this direction is certainly not less than that made in geometry, I will ask your attention to one or two points which stand notably prominent.

In algebra we use ordinary equations involving one unknown quantity; in the application of algebra to geometry we meet with equations, representing curves or surfaces, and involving two or three unknown quantities respectively; in the theory of probabilities, and in other branches of research, we employ still more general expressions. Now, the modern algebra, originating with Cayley and Sylvester, regards all these diverse expressions as belonging to one and the same family, and comprises them all under the same general term "quantics." Studied from this point of view, they all alike give rise to a class of derivative forms, previously unnoticed, but now known as invariants, covariants, canonical forms, etc. By means of these, mathematicians have arrived not only at many properties of the quantics themselves, but also at their application to physical problems. It would be a long and perhaps invidious task to enumerate the many workers in this fertile field of research, especially in the schools of Germany and of Italy; but it is perhaps the less necessary to do so, because Sylvester, aided by a young and vigorous staff at Baltimore, is welding many of these results into a homogeneous mass in the classical memoirs which are appearing from time to time in the "American Journal of Mathematics."

In order to remove any impression that these extensions of algebra are merely barren speculations of ingenious intellects, I may add that many of these derivative forms, at least in their elementary stages, have already found their way into the text-books of mathematics; and one class in particular, known by the name of determinants, is now introduced as a recognized method of algebra, greatly to the convenience of all those who become masters of its use.

In the extension of mathematics it has happened more than once that laws have been established so simple in form, and so obvious in their necessity, as scarcely to require proof. And yet their application is often of the highest importance in checking conclusions which have been drawn from other considerations, as well as in leading to conclusions which, without their aid, might have been difficult of attainment. The same thing has occurred also in physics; and notably in the recognition of what has been termed the "law of the conservation of energy."

Energy has been defined to be "the capacity, or power, of any body, or system of bodies, when in a given condition, to do a measurable quantity of work." Such work may either change the condition of the bodies in question, or it may affect other bodies; but in either case energy is expended by the agent upon the recipient in performance of the work. The law then states that the total amount of energy in the agents and recipients taken together remains unaltered by the changes in question.

Now, the principle on which the law depends is this—"that every kind of change among the bodies may be expressed numerically in one standard unit of change," viz., work done, in such wise that the result of the passage of any system from one condition to another may be calculated by mere additions and subtractions, even when we do not know how the change came about. This being so, all work done by a system may be expressed as a diminution of energy of that system, and all work done upon a system as an accession of energy. Consequently, the energy lost by one system in performance of work will be gained by another in having work done upon it, and the total energy, as between the two systems, will remain unchanged.

There are two cases, or conditions, of energy which, although substantially the same, are for convenience regarded separately. These may be illustrated by the following example: Work may be done upon a body, and energy communicated to it, by setting it in motion, e. g., by lifting it against gravity. Suppose this to be done by a spring and detent; and suppose, further, the body, on reaching its highest point, to be caught so as to rest at that level on a support. Then, whether we consider the body at the moment of starting, or when resting on the support, it has equally received an accession of energy from the spring, and is therefore equally capable of communicating energy to a third body. But in the one case this is due to the motion

which it has acquired, and in the other to the position at which it rests, and to its capability of falling again when the support is removed. Energy in the first of these states is called "Energy of Motion," or "Kinetic Energy," and that in the second state, "Energy of Position," or "Potential Energy." In the case supposed, at the moment of starting, the whole of the energy is kinetic; as the body rises, the energy becomes partly potential and partly kinetic; and when it reaches the highest point the energy has become wholly potential. If the body be again dropped, the process is reversed.

The history of a discovery, or invention, so simple at first sight, is often found to be more complicated the more thoroughly it is examined. That which at first seems to have been due to a single mind proves to have been the result of the successive action of many minds. Attempts more or less successful in the same direction are frequently traced out; and even unsuccessful efforts may not have been without influence on minds turned toward the same object. Lastly, also, germs of thought, originally not fully understood, sometimes prove in the end to have been the first stages of growth toward ultimate fruit. The history of the law of the conservation of energy forms no exception to this order of events. There are those who discern even in the writings of Newton expressions which show that he was in possession of some ideas which, if followed out in a direct line of thought, would lead to those now entertained on the subjects of energy and of work. But, however this may be, and whosoever might be reckoned among the earlier contributors to the general subject of energy, and to the establishment of its laws, it is certain that within the period of which I am now speaking, the names of Séguin, Clausius, Helmholtz, Mayer, and Colding, on the Continent, and those of Grove, Joule, Rankine, and Thomson, in this country, will always be associated with this great work.

I must not, however, quit this subject without a passing notice of a conclusion to which Sir William Thomson has come, and in which he is followed by others who have pursued the transformation of energy to some of its ultimate consequences. The nature of this will perhaps be most easily apprehended by reference to a single instance. In a steam-engine, or other engine, in which the motive power depends upon heat, it is well known that the source of power lies not in the general temperature of the whole, but merely on the difference of temperature between that of the boiler and that of the condenser. And the effect of the condenser is to reduce the steam issuing from the boiler to the same temperature as the condenser. When this is once done, no more work can be got out of the engine, unless fresh heat be supplied from an outside source to the boiler. The heat originally communicated to the boiler has become uniformly diffused, and the energy due to that difference is said to have been dissipated. The energy remains in a potential condition as regards other bodies; but as regards the engine, it is of no further use. Now, suppose that we

regard the entire material universe as a gigantic engine, and that after long use we have exhausted all the fuel (in its most general sense) in the world; then all the energy available will have become dissipated, and we shall have arrived at a condition of things from which there is no apparent escape.

Professor Frankland has been so good as to draw up for me the following account of the progress of chemistry during the last half-century: Most of the elements had been discovered before 1830, the majority of the rarer elements since the beginning of the century. In addition to these the following five have been discovered, three of them by Mosander, viz.: lanthanum in 1839, didymium in 1842, and erbium in 1843. Ruthenium was discovered by Claus in 1843, and niobium by Rose in 1844. Spectrum analysis has added five to the list, viz.: cæsium and rubidium, which were discovered by Bunsen and Kirchhoff in 1860; thallium, by Crookes in 1861; indium, by Reich and Richter in 1863; and gallium, by Lecoq de Boisbaudran in 1875.

As regards theoretical views, the atomic theory, the foundation of scientific chemistry, had been propounded by Dalton (1804–1808). The three laws which have been chiefly instrumental in establishing the true atomic weights of the elements—the law of Avogadro (1811), that equal volumes of gases, under the same conditions of temperature and pressure, contain equal numbers of molecules; the law of Dulong and Petit (1819), that the capacities for heat of the atoms of the various elements are equal; and Mitscherlich's law of isomorphism (1819), according to which equal numbers of atoms of elements belonging to the same class may replace each other in a compound without altering the crystalline form of the latter—had been enunciated in quick succession; but the true application of these three laws, though in every case distinctly stated by the discoverers, failed to be generally made, and it was not till the rectification of the atomic weights by Cannizzaro, in 1858, that these important discoveries bore fruit.

In organic chemistry the views most generally held about the year 1830 were expressed in the radical theory of Berzelius. This theory, which was first stated in its electro-chemical and dualistic form by its author in 1817, received a further development at his hands in 1834, after the discovery of the benzoyl-radical by Liebig and Wöhler. In the same year (1834), however, a discovery was made by Dumas, which was destined profoundly to modify the electro-chemical portion of the theory, and even to overthrow the form of it put forth by Berzelius. Dumas showed that an electro-negative element, such as chlorine, might replace, atom for atom, an electro-positive element like hydrogen, in some cases without much alteration in the character of the compound. This law of substitution has formed a necessary portion of every chemical theory which has been proposed since its discovery,

and its importance has increased with the progress of the science. It would take too long to enumerate all the theoretical views which have prevailed at various times during the past fifty years; but the theory which along with the radical theory has exercised most influence on the development of the views now held, is the theory of types, first stated by Dumas (1839), and developed in a different form and amalgamated with the radical theory by Gerhardt and Williamson (1848–1852). It is, however, the less necessary to refer in detail to these views, seeing that in the now prevailing theory of atomicity we possess a generalization which, while greatly extending the scope of chemical science in its power of classifying known and predicting unknown facts, includes all that was valuable in the generalizations which preceded it. The study of the behavior of organo-metallic compounds in chemical reactions led to the conclusion that various metallic elements possess a definite capacity of saturation with regard to the number of atoms of other elements with which they can combine, and demonstrated this regularity of atom-fixing power in the case of zinc, tin, arsenic, and antimony. A serious obstacle, however, in the way of determining the true atomicities of the elements was the general employment of the old so-called equivalent weights, which were by most chemists confounded with the atomic weights. This difficulty was removed by the rectification of the atomic weights, which, though begun by Gerhardt as early as 1842, met for a long time with but little recognition, and was not completed till the subject was taken up by Cannizzaro in 1858. The law of atomicity has given to chemistry an exactness which it did not previously possess, and since its discovery and recognition chemical research has moved very much on the lines laid down by this law.

Chemists have been engaged in determining, by means of decompositions, the molecular architecture, or *constitution* as it is called, of various compounds, natural and artificial, and in verifying by synthesis the correctness of the views thus arrived at.

It was long supposed that an impassable barrier existed between inorganic and organic substances: that the chemist could make the former in his laboratory, while the latter could only be produced in the living bodies of animals or plants—requiring for their construction not only chemical attractions, but a supposed "vital force." It was not until 1828 that Wöhler broke down this barrier by the synthetic production of urea, and since his time this branch of science in the hands of Hofmann, Wurtz, Berthelot, Butlerow, and others, has made great strides.

Innumerable natural compounds have thus been produced in the laboratory—ranging from bodies of relatively simple constitution, such as the alcohols and acids of the fatty series, to bodies of such complex molecular structure as alizarine (the principal coloring-matter of madder), coumarine (the odoriferous principle of the Tonka bean), vanilline,

and indigo. The problem of the natural alkaloids has also been attacked, in some cases with more than partial success. Methylconine, which occurs along with conine in the hemlock, has been recently prepared artificially by Michael and Gundelach, this being the first instance of the synthesis of a natural alkaloid. A proximate synthesis of atropine, the alkaloid of the deadly nightshade, has been accomplished by Ladenburg. It seems further probable that at no distant date the useful alkaloids, such as quinine, may also be synthesized, inasmuch as quinoline, one of the products of the decomposition of quinine and of some of the allied bases, has recently been prepared by Skraup by a method which admits of its being obtained in any quantity.

Much also has been done in the way of building up compounds the existence of which was predicted by theory. Indeed, the extent to which hitherto undiscovered substances can be predicated is doubtless the greatest triumph achieved by chemists during the past fifty years.

As yet, however, only the statical side of chemistry has been developed. While the physicist has been engaged in tracing, for the gaseous condition at least, the paths of the molecules and calculating their velocities, the chemist, whose business is with the atoms within the molecule, can point to no such scientific conquests. All that he knows concerning the intramolecular atoms and all that he expresses in his constitutional formulæ is, the particular relation of union in which each of these atoms stands to the others—which of them are directly united (as he expresses it) to other given atoms, and which of them are in indirect union. Of the relative positions in space occupied by these atoms, and of their modes of motion, he is absolutely ignorant. In like manner, in a chemical reaction, the initial and final conditions of the reacting substances are known, but the intermediate stages—the modes of change—are for the most part unexplained.

Owing to a feeling that no number, however great, of successfully solved problems of constitutional chemistry (as at present understood), and no number of syntheses, however brilliant, of natural compounds could raise chemistry above the statical stage—that the solution of the dynamical problem can not be arrived at by purely chemical means—has led many chemists to approach the subject from the physical side. The results which the physico-chemical methods, as exemplified in the laws already alluded to of Dulong and Petit, Avogadro, and Mitscherlich, have yielded in the past, offer the best guarantee of their success in the future. And the advantages of many of the physical methods are obvious. Every purely chemical examination—whether proximate or ultimate—of a compound, presupposes the destruction of the substance under examination: the chemist "murders to dissect." But observations on the action of a substance on the rays of light, on the relative volumes occupied by molecular quantities of a substance, on its velocity of transpiration in the liquid or gaseous state—these

teach us the habits of the living substance. The rays of light which have threaded their way between the molecules of a body have undergone, in contact with these molecules, various specific and measurable changes, the nature and amount of which are assuredly conditioned by the mass, form, and other properties of the molecules: the plane of polarization has been caused to rotate; a particular degree of refraction has been imparted; or rays of certain wave-lengths have been removed by absorption, their absence being manifested by bands in the absorption spectrum of the substance. The volumes occupied by molecular quantities are dependent partly on the size of the molecules and partly on that of the intermolecular spaces.

The duty of the physical chemist is to endeavor to co-ordinate his physical observations with the known constitution of compounds as already determined by the pure chemist. This endeavor has in various branches of physical chemistry been to some extent successful. Le Bel has found that among organic compounds those only possess action on the plane of polarized light which contain at least one *asymmetric carbon-atom*—that is to say, a carbon-atom which is united to four *different* atoms or groups of atoms. The researches of Landolt, of Gladstone, and of Brühl on the specific refraction of organic liquids, have shown that from the known constitution of a liquid organic compound it is possible to calculate its specific refraction. Noel Hartley, in an examination of the absorption spectra of organic liquids for the ultra-violet rays, has demonstrated that certain molecular groupings are represented by particular absorption bands, and this line of inquiry has been extended with very interesting results to the ultra-red rays by Abney and Festing. It is obvious that these methods may in turn be employed to determine the unknown constitution of substances. The same holds true of the investigations of Kopp with regard to the molecular volumes of liquids at their boiling-points, in which he has established the remarkable fact that some elements always possess the same atomic volume in combination, whereas, in the case of certain other elements, the atomic volume varies in a perfectly definite manner with the mode of combination. This investigation has lately been extended with the best results by Thorpe and by Ramsay. Thermo-chemistry, also, which for a long time, at least as regards that portion which relates to the heat of formation of compounds, consisted chiefly of a collection of single equations, each containing three unknown quantities, is beginning to be interpreted by Julius Thomsen, whose experimental work in this field is well known. Many other methods of physico-chemical research are being successfully prosecuted at the present day, but it would go beyond the bounds of this summary even to enumerate these.

The concordant results obtained by these widely differing methods show that those chemists who have devoted themselves, frequently amid the ridicule of their more practical brethren, to ascertaining by

purely chemical methods the constitution of compounds, have not labored in vain. But the future doubtless belongs to physical chemistry.

In connection with the rectification of the atomic weights it may be mentioned that a so-called natural system of the elements has been introduced by Mendelejeff (1869), in which the properties of the elements appear as a periodic function of their atomic weights. By the aid of this system it has been possible to predict the properties and atomic weights of undiscovered elements, and in the case of known elements to determine many atomic weights which had not been fixed by any of the usual methods. Several of these predictions have been verified in a remarkable manner. A periodicity in the atomic weights of elements belonging to the same class had been pointed out by Newlands about four years before the publication of Mendelejeff's memoir.

In mechanical science the progress has not been less remarkable than in other branches. Indeed, to the improvements in mechanics we owe no small part of our advance in practical civilization, and of the increase of our national prosperity during the last fifty years. This immense development of mechanical science has been to a great extent a consequence of the new processes which have been adopted in the manufacture of iron, for the following data with reference to which I am indebted to Captain Douglas Galton. About 1830, Neilson introduced the hot blast in the smelting of iron. At first a temperature of 600° or 700° Fahr. was obtained, but Cowper subsequently applied Siemens's regenerative furnace for heating the blast, chiefly by means of fumes from the black furnace, which were formerly wasted; and the temperature now practically in use is as much as 1,400°, or even more: the result is a very great economy of fuel and an increase of the output. For instance, in 1830, a blast-furnace with the cold blast would probably produce 130 tons per week, whereas now 600 tons a week are readily obtained.

Bessemer, by his brilliant discovery, which he first brought before the British Association at Cheltenham in 1856, showed that iron and steel could be produced by forcing currents of atmospheric air through fluid pig-metal, thus avoiding for the first time the intermediate process of puddling iron, and converting it by cementation into steel. Similarly, by Siemens's regenerative furnace, the pig-metal and iron-ore are converted directly into steel, especially mild steel for ship-building and boilers; and Whitworth, by his fluid compression of steel, is enabled to produce steel in the highest condition of density and strength of which the metal is capable. These changes, by which steel can be produced direct from the blast-furnace instead of by the more cumbersome processes formerly in use, have been followed by improvements in manipulation of the metal.

The inventions of Cort and others were known long before 1830, but we were then still without the most powerful tool in the hands of

the practical metallurgist, viz., Nasmyth's steam-hammer. Steel can be produced as cheaply as iron was formerly; and its substitution for iron, as railway material and in ship-building, has resulted in increased safety in railway-traveling, as well as in economy, from its vastly greater durability. Moreover, the enlarged use of iron and steel, which has resulted from these improvements in its make, has led to the adoption of mechanical means to supersede hand-labor in almost every branch of trade and agriculture, by which the power of production has been increased a hundred-fold, while at the same time much higher precision has been obtained. Sir Joseph Whitworth has done more than any one else to perfect the machinery of this country by the continued efforts he has made, during nearly half a century, to introduce accuracy into the standards of measurement in use in workshops. He tells us that, when he first established his works, no two articles could be made accurately alike or with interchangeable parts. He devised a measuring apparatus, by which his workmen in making standard gauges are accustomed to take measurements to the $\frac{1}{20000}$ of an inch.

In its more immediate relation to the objects of this Association, the increased importance of iron and steel has led to numerous scientific investigations into their mechanical properties and into the laws which govern their strength; into the proper distribution of the material in construction; and into the conditions which govern the friction and adhesion of surfaces. The names of Eaton Hodgkinson, Fairbairn, Barlow, Rennie, Scott Russell, Willis, Fleeming Jenkin, and Galton, are prominently associated with these inquiries.

The introduction of iron has, moreover, had a vast influence on the works of both the civil and military engineer. Before 1830, Telford had constructed an iron suspension turnpike-road bridge of 560 feet over the Menai Straits; but this bridge was not adapted to the heavy weights of locomotive-engines. At the present time, with steel at his command, Mr. Fowler is engaged in carrying out the design for a railway-bridge over the Forth, of two spans of 1,700 feet each—that is to say, of nearly one third of a mile in length. In artillery, bronze has given place to wrought-iron and steel; the 68-pound shot, which was the heaviest projectile fifty years ago, with its range of about 1,200 yards, is being replaced by a shot of nearly a quarter-ton weight, with a range of nearly five miles; and the armor-plates of ships are daily obtaining new developments.

But it is in railroads, steamers, and the electric telegraph, that the progress of mechanical science has most strikingly contributed to the welfare of man. To the latter I have already referred. As regards railways, the Stockton and Darlington Railway was opened in 1825; but the Liverpool and Manchester Railway, perhaps the first truly passenger line, dates from 1830; while the present mileage of railways is over 200,000 miles, costing nearly £4,000,000,000 sterling. It was

not until 1838 that the Sirius and Great Western first steamed across the Atlantic. The steamer, in fact, is an excellent epitome of the progress of the half-century; the paddle has been superseded by the screw; the compound has replaced the simple engine; wood has given place to iron, and iron in its turn to steel. The saving in dead weight, by this improvement alone, is from ten to sixteen per cent. The speed has been increased from nine knots to fifteen, or even more. Lastly, the steam-pressure has been increased from less than five pounds to seventy pounds per square inch, while the consumption of coal has been brought down from five or six pounds per horse-power to less than two. It is a remarkable fact that not only is our British shipping rapidly on the increase, but it is increasing relatively to that of the rest of the world. In 1860 our tonnage was 5,700,000 against 7,200,000; while it may now be placed as 8,500,000 against 8,200,000; so that considerably more than half the whole shipping of the world belongs to this country.

If I say little with reference to economic science and statistics, it is because time, not materials, is wanting.

I scarcely think that, in the present state of the question, I can be accused of wandering into politics if I observe that the establishment of the doctrine of free trade as a scientific truth falls within the period under review.

In education some progress has been made toward a more rational system. When I was at a public school, neither science, modern languages, nor arithmetic formed any part of the school system. This is now happily changed. Much, however, still remains to be done. Too little time is still devoted to French and German, and it is much to be regretted that even in some of our best schools they are taught as dead languages. Lastly, with few exceptions, only one or two hours on an average are devoted to science. We have, I am sure, none of us any desire to exclude or discourage literature. What we ask is that, say, six hours a week each should be devoted to mathematics, modern languages, and science, an arrangement which would still leave twenty hours for Latin and Greek. I admit the difficulties which schoolmasters have to contend with; nevertheless, when we consider what science has done and is doing for us, we can not but consider that our present system of education is, in the words of the Duke of Devonshire's commission, little less than a national misfortune.

In agriculture the changes which have occurred in the period since 1831 have been immense. The last half-century has witnessed the introduction of the modern system of subsoil drainage founded on the experiments of Smith, of Deanston. The thrashing and drilling machines were the most advanced forms of machinery in use in 1831. Since then there have been introduced the steam-plow; the mowing-machine; the reaping-machine, which not only cuts the corn but binds it into sheaves; while the steam-engine thrashes out the grain and

builds the ricks. Science has thus greatly reduced the actual cost of labor, and yet it has increased the wages of the laborer.

It was to the British Association, at Glasgow, in 1841, that Baron Liebig first communicated his work "On the Application of Chemistry to Vegetable Physiology," while we have also from time to time received accounts of the persevering and important experiments which Mr. Lawes, with the assistance of Dr. Gilbert, has now carried on for more than forty years at Rothamsted, and which have given so great an impulse to agriculture by directing attention to the principles of cropping, and by leading to the more philosophical application of manures.

I feel that, in quitting Section F so soon, I owe an apology to our fellow-workers in that branch of science, but I doubt not that my shortcomings will be more than made up for by the address of their excellent President, Mr. Grant-Duff, whose appointment to the governorship of Madras, while occasioning so sad a loss to his friends, will unquestionably prove a great advantage to India, and materially conduce to the progress of science in that country.

Moreover, several other subjects of much importance, which might have been referred to in connection with these latter sections, I have already dealt with under their more purely scientific aspect.

Indeed, one very marked feature in modern discovery is the manner in which distinct branches of science have thrown, and are throwing, light on one another. Thus the study of geographical distribution of living beings, to the knowledge of which our late general secretary, Mr. Sclater, has so greatly contributed, has done much to illustrate ancient geography. The existence of high northern forms in the Pyrenees and Alps points to the existence of a period of cold when Arctic species occupied the whole of habitable Europe. Wallace's line—as it has been justly named after that distinguished naturalist—points to the very ancient separation between the Malayan and Australian regions; and the study of corals has thown light upon the nature and significance of atolls and barrier-reefs.

In studying the antiquity of man, the archæologist has to invoke the aid of the chemist, the geologist, the physicist, and the mathematician. The recent progress in astronomy is greatly due to physics and chemistry. In geology the composition of rocks is a question of chemistry; the determination of the boundaries of the different formations falls within the limits of geography; while paleontology is the biology of the past.

And now I must conclude. I fear I ought to apologize to you for keeping you so long, but still more strongly do I wish to express my regret that there are almost innumerable researches of great interest and importance which fall within the last fifty years (many even among those with which our Association has been connected) to which I have

found it impossible to refer. Such for instance are, in biology alone, Owen's memorable report on the homologies of the vertebrate skeleton; Carpenter's laborious researches on the microscopic structure of shells; the reports on marine zoölogy by Allman, Forbes, Jeffreys, Spence Bate, Norman, and others; on Kent's Cavern by Pengelly; those by Duncan on corals; Woodward on crustaceæ; Carruthers, Williamson, and others on fossil botany, and many more. Indeed, no one who has not had occasion to study the progress of science throughout its various departments can have any idea how enormous—how unprecedented—the advance has been.

Though it is difficult, indeed impossible, to measure exactly the extent of the influence exercised by this Association, no one can doubt that it has been very considerable. For my own part, I must acknowledge with gratitude how much the interest of my life has been enhanced by the stimulus of our meetings, by the lectures and memoirs to which I have had the advantage of listening, and, above all, by the many friendships which I owe to this Association.

Summing up the principal results which have been attained in the last half-century we may mention (over and above the accumulation of facts) the theory of evolution, the antiquity of man, and the far greater antiquity of the world itself; the correlation of physical force and the conservation of energy; spectrum analysis and its application to celestial physics; the higher algebra and the modern geometry; lastly, the innumerable applications of science to practical life—as, for instance, in photography, the locomotive-engine, the electric telegraph, the spectroscope, and most recently the electric light and the telephone.

To science again we owe the idea of progress. The ancients, says Bagehot, "had no conception of progress; they did not so much as reject the idea; they did not even entertain it." It is not, I think, now going too far to say that the true test of the civilization of a nation must be measured by its progress in science. It is often said, however, that great and unexpected as the recent discoveries have been, there are certain ultimate problems which must ever remain unsolved. For my part, I would prefer to abstain from laying down any such limitations. When Park asked the Arabs what became of the sun at night, and whether the sun was always the same, or new each day, they replied that such a question was childish, and entirely beyond the reach of human investigation. I have already mentioned that, even as lately as 1842, so high an authority as Comte treated as obviously impossible and hopeless any attempt to determine the chemical composition of the heavenly bodies. Doubtless there are questions, the solution of which we do not as yet see our way even to attempt; nevertheless the experience of the past warns us not to limit the possibilities of the future.

But, however this may be, though the progress made has been so rapid, and though no similar period in the world's history has been

nearly so prolific of great results, yet, on the other hand, the prospects of the future were never more encouraging. We must not, indeed, shut our eyes to the possibility of failure: the temptation to military ambition; the tendency to over-interference by the state; the spirit of anarchy and socialism—these and other elements of danger may mar the fair prospects of the future. That they will succeed, however, in doing so, I can not believe. I can not but feel confident hope that fifty years hence, when perhaps the city of York may renew its hospitable invitation, my successor in this chair—more competent, I trust, that I have been to do justice to so grand a theme—will have to record a series of discoveries even more unexpected and more brilliant than those which I have, I fear so imperfectly, attempted to bring before you this evening. For one great lesson which science teaches is, how little we yet know, and how much we have still to learn.

CATHOLICISM, PROTESTANTISM, AND SUICIDE.*

By HENRY MORSELLI, M. D.

THE influences of religion are, together with the influence of race, the strongest motive powers which act on the will of man. The discussion as to whether the growth of suicide is to be accounted for by the decrease of religious sentiment scarcely finds place in a work like this. It is a thesis generally put forward by moralists whose opinion approaches our own on this subject. On the other hand, the theme of the special influence of the various faiths, which statisticians have sought to dispute, presents itself to us, two kinds of proof being deduced therefrom. The first is furnished by the indication of the form of worship to which suicides belong; but, unfortunately, this is represented in very few statistics of Central Europe, and is not always adapted to each case in particular. The second is the approximate relation between the number of violent deaths and the predominant form of worship in given countries; and here the most fertile in results are the statistics of the states having inhabitants of various forms of worship, as Prussia, Germany, Austria, Holland, and Switzerland. The countries of the south, Italy, Spain, and France, have so small a number of non-Catholics that little or no comparative result could be obtained from it. We notice again that, in the comparisons based on the religion of suicides, Judaism figures, in which the influence of religious bonds is complicated with that of race. This is perhaps the only religion bound up in the fate of a single people, whether on account of the exclusiveness of the Mosaic laws, or be-

* From advance sheets of Dr. Morselli's new book on suicide. As the tables can not be here well given, the references to them are omitted.

cause no other race is so jealous of its own purity, its own customs, and especially of the faith of its fathers, as the Jewish. In every country where the *chosen* people has been spread, it has always preserved the moral Semitic character, while it has sometimes modified its physical characteristics, as when becoming fair where formerly dark-skinned; the religion of the God of Abraham is the only bond which now unites its scattered members. This strong influence of race obliges one to proceed cautiously in attributing to the Mosaic religion the little tendency of Jews toward suicide. In the most ancient history of Palestine not more than ten suicides are mentioned, and their greatest number belongs to a less pure Jewish period, when, through the Babylonish captivity and through the false prophets, they lost all trace of the ancient law. Already, among the last Jews who had to struggle against the invading Roman power, suicide had become more frequent (Josephus); but, while dispersing themselves among other nations over the face of the earth, the descendants of Abraham have always shown and still show among their moral characteristics an habitual resistance to suicide, although the same can not be said with regard to madness.

The influence of other religions may be studied without being perplexed with the question of race. It is true that the people called Latins have remained faithful to Catholicism, while the reform of religious thought was the exclusive work of the Anglo-Germans; but it is likewise true that, in countries of mixed religions, statistics have always shown the hurtful or beneficial effect of each. At first sight it is indeed perceived that the purely Catholic nations, Italy, Spain, and Portugal, stand on the last step of the scale of suicide, while those exclusively or mostly Protestant take the first grade; it suffices to cite Saxony, Denmark, Scandinavia, and Prussia. In countries of mixed religions, then, the inclination toward suicide diminishes in direct ratio to the predominance of Catholicism. Looking at the aggregate of statistics collected by us for the most recent years, it is inferred that the frequency of suicide is, in states of Catholic religion, on an average of 58 per million; in Protestant states, 190; in the United or non-united Greek, 40; where there is a mixture of Catholic, Protestant, and other sects, 96 per million. Countries of the Greek religion, then, give the smallest proportion; but here comes in the great influence of Slavism, which would be sufficient to neutralize all others, as we already found was the case with regard to climate and anthropological characteristics. With our results, those of Wagner, Oettingen, and Legoyt agree; this latter author having calculated, on the statistical documents of Bavaria, Prussia, Würtemberg, and Austria, that the tendency to suicide is, among Protestants, 102·7 per million individuals; among Catholics, 62·3; among other Christians (Greeks, United and the Orthodox) 36·2; and lastly, among the Jews, 48·4 per million.

But much more correct than this comprehensive comparison is that between the proselytes of different religions in the same country, because then the political and social conditions do not vary, and the due homogeneity of comparative data remains the same. Statistics, however, are liable to another error; in most cases the religion of the suicide is not registered, and the column of the unknown always predominates over the others. It is sufficient to cite the Prussian statistics of the two years 1871–'72, in which, out of 5,673 registered suicides, quite 3,703 (65 per cent.) can give no answer to the question of the religion professed by the suicides. Nevertheless, we have been able to ascertain the frequency of suicide among individuals of different religions in thirty-seven countries, as our tables show.

In these thirty-seven comparisons of different countries and periods, hardly four show the Catholics superior in numbers of suicides to Protestants, Jews, and Greeks (Galicia, Buckowina, Military Frontiers, and Transylvania), and one only, also with doubts as to its being an error, gives the higher number to the Jews (? Lower Austria); but in the remainder the larger proportions are always offered by the Protestant religion, whether Lutheran or Reformed. The most frequent order in which the various religions follow each other is this: *Protestants*, *Catholics*, and *Jews;* and next in order of frequency come *Protestants*, *Jews*, and *Catholics*. Looking next at the position held by the Oriental Christians, it will be found that once only, and then it was among the Greek Catholics or Uniates, they gave the largest proportion to suicide (Military Frontiers); as a rule, their proportion is always lower than that of the Protestants, often also than that of the Catholics of the West. The inferiority in numbers of the Greeks is most apparent in Transylvania, where the Catholics occupy the first place, followed by the Uniates, then by the Lutherans and Calvinists, and lastly, at a long interval, by the United or non-united Greeks. The peculiar position occupied by Jews in relation to Catholics deserves attentive investigation. Jews are in general more subject to mental alienation than either Catholics or Protestants. In Bavaria, for instance, we find one insane in every 908 Catholic inhabitants, in every 967 Protestants, and every 514 Jews. In Hanover the reports give respectively one in 527 Catholics, in 641 Protestants, and in every 337 Jews. In Würtemberg one in every 2,006 Catholics, in 2,022 Protestants, and in 1,544 Jews; and in Denmark in like manner, while there is one insane person in every 1,750 among the Jewish population, there is one in every 2,000 of other religions. In Italy also, since the asylums have been opened to Jews, their contingent has been very considerable (Lambroso, Livi). Is the explanation to be sought in their race, their religion, or their customs? Dr. Martini (of Leubus) would refer it to their frequent consanguineous marriages; but in truth the supposed evils arising from the consanguinity of parents have yet to be proved. To us it seems more

correct to regard it as the consequence of the mode of life and habits of the Hebrew people, who are always to be found living in crowded cities (excepting, perhaps, the numerous Jewish population of Galicia, Poland, and Buckowina); and the professions they follow are more liable than others to commercial crises and the constant vicissitudes of trade.

With regard to suicide, on the other hand, the Jews of various countries differ more among themselves than Catholics from Protestants, who maintain a certain relative proportion with little variation. Great anthropological and social diversities are indeed to be observed between the Jews of Poland, Galicia, and Russia of the Dnieper, where they are very numerous and exercise an important influence on public affairs, and those of Central Europe, and in general of Catholic or mixed Catholic countries, where they have had to struggle through so many centuries against religious intolerance.

The very high average of suicides among Protestants is another fact too general to escape being ascribed to the influence of religion. Protestantism, denying all materialism in external worship and encouraging free inquiry into dogmas and creeds, is an eminently mystic religion, tending to develop the reflective powers of the mind and to exaggerate the inward struggles of the conscience. This exercise of the thinking organs, which, when they are weak by nature, is always damaging, renders them yet more sensible and susceptible of morbid impressions. Protestantism in the German states further exercises this exciting influence on the cerebral functions in yet another manner: it originated those philosophical systems which are based on the naturalistic conception of human existence, and put forward the view that the life of the individual is but a simple function of a great whole. These philosophical ideas are harmless enough to strong minds and those stored with a fit provision of scientific culture, but in the democratic atmosphere of our times the heart is not educated *pari passu*. The religious apathy with which the present generation is afflicted does not arise from a reasoned inquiry into the laws of nature or a scientific appreciation of its phenomena; it is not, in short, a deep conviction of the mind, but springs from a physical inertia, and from the little hold obtained by any ideas but such as are directed to material improvement and the gratification of ambition. To our mind, therefore, the great number of suicides is to be attributed to the state of compromise which the human mind occupies at the present time between the metaphysical and the positivist phase of civilization, and as this transition is more active in countries of marked mystic and metaphysical tendencies, such as is the case with Protestantism, it is natural that in them suicide should have the greatest number of victims.

It is obvious that a great difference generally exists between Catholic and Protestant countries only, not between the Catholic and

Protestant inhabitants of the same country. Where the tendency to suicide is great among the latter, it will be found to be also high among the former, as may be observed from the statistics already quoted of Baden, Würtemberg, Franconia, Galicia, Bavaria, etc. This follows from the moral and social condition of the various religionists being rendered locally identical. Wagner, Oettingen, and Legoyt reckon that they have established, from their study of the influence of religion on this matter, that "*the inclination toward suicide in the inhabitants belonging to any particular worship, in any given country, will diminish in direct ratio with their numerical inferiority.*" According to Legoyt, suicide more rarely occurs in those persuasions which are numerically weak, because the struggle with the hostility and intolerance of the population in the midst of whom they live exercises on them a sort of moral coercion, making them desirous to avoid the harsh judgment held over them. As a matter of theory we can not deny the truth of this conclusion of Legoyt, as we well know how the spirit of association and the earnestness of religious convictions increase in proportion to the isolation into which any given congregation is cast when in the minority in a country. This influence of the surrounding atmosphere on religion is proved by the persistence and tenacity of the transmission of the Mosaic law through so many ages and migrations, and may explain the small tendency toward suicide among Jews. But at the same time an attentive examination of facts does not altogether bear out Legoyt's conclusion; for we find that it is scarcely ever that minorities furnish the smallest contingent to the register of suicide. For example, in Lower Bavaria, where Protestants are barely $\frac{8}{100}$ of the population, we find one hundred and forty-eight suicides in a million among them, whereas among Catholics, who compose nine tenths of the population, the number of suicides amounts to hardly twenty-eight in a million. In Brandenburg, where the Catholics are scarcely $\frac{3}{100}$ of the population, they show a threefold greater inclination for suicide than in Saxony, where they form *half the population*. And in Austria the Catholics, although in a minority in Galicia, Buckowina, the Military Frontiers, and Transylvania, yet show a greater tendency to suicide than either Greeks, Uniates, or Jews. The exceptions to the rule, therefore, are more numerous than the examples which should establish it. So far from it, if we consider the aggregate of the various countries of Europe, and that at the *latest statistical period*, it is easy to perceive that, where religious toleration has made more way, minorities begin to approximate the general average of their religion, the moral coercion of which Legoyt speaks is fast disappearing, and the unmixed influence of religion begins to tell with full force. The same thing happens with the Protestants of Baden, Würtemberg, and Austria, and in fact everywhere; notwithstanding that they form the minority, and in some cases a very considerable minority, the average of suicide is everywhere higher than that of the

Catholics. If a numerical inferiority were to operate at the present time in reproducing the tendency to suicide, we should not find it, as we do, much more frequent among the Jews of Bavaria, and especially in Lower Franconia and the Archduchy of Austria, than among the Catholics, although they form but a small fraction of the population.

With regard to the influence of religion in this matter, the only one fact which as yet has been well proved is the higher rate of suicides among Protestants than among Catholics, as appears from our tables, in which, along with the average of various states and provinces, we have given the proportions of the inhabitants belonging to the two faiths. A very considerable difference will be found, particularly in countries of mixed creeds, where those in which Protestants predominate are always visited with the greatest number of violent deaths. It needs but to compare the mixed Cantons of Switzerland, the Circles of Prussia, Hanover, and Baden, and the provinces of Holland. And it is observable that, while there certainly are Catholic countries which supply a high average (such as the departments of the Ile de France and the Orleannais), no Protestant country has figures that will bear comparison with the lowest of those of certain Catholic countries of the south of Europe. The influence of Paris is such as altogether to neutralize that of religion; but, for so considerable a rise in the average of the northeast of France, we must take into account the introduction of the Germanic ethnical element, for there the religious apathy which springs from the habits of our times has not yet taken sufficient effect to tell upon statistics.

A MAP REVIEW.

By FRANK D. Y. CARPENTER, C. E.

EVERY new scientific book is duly noticed, and every meritorious painting or other work of art receives its critical mention, but we have yet to see, in this country, any review of that combination of science and art—a geographical map. Such a map, worthy in more ways than one of the attention of engineer and artist, has just been completed in the Washington office of the geographical surveys of the United States Engineer Bureau, and as a posthumous publication of these surveys, now discontinued, its appearance may awaken a sense of regret over the end of an organization which was capable of producing such excellent results. It has already won the highest honors at the Geographical Congress of Venice, where the original drawing and a photo-lithographic proof were exhibited in September last.

This sheet was designed by Captain Wheeler, in charge of this work, to illustrate the methods of map-making, peculiarly American

and adapted to our extensive territory, which have been developed in this country within the last quarter of a century, through the successive mediums of the itineraries of exploring parties, the various boundary surveys, Whitney's California Survey, Clarence King's Fortieth-Parallel Survey, Hayden's and Powell's geological surveys, and the geographical surveys and other frontier operations of the Engineer Bureau. The methods in question combine the rapid reconnaissance, the mountain sketch, and the barometrical height upon a precise geodetic basis, incorporating all reliable information attainable from other sources, especially the land-surveys, which give certain points in roads and streams, and the perimeters of valleys and areas of water. In the end we have a map of which the error is, in general, inappreciable, and the cost in time and money is comparatively insignificant. Yet so faithfully may the features of a country be portrayed in this way, that the map of Lake Tahoe, the subject of this note, is sufficient to guide the engineer in his projects, the geologist in his studies, the tourist on his travels, the soldier on his march, and the emigrant in his search for a home.

So much for its usefulness, which is the first and principal mission of a map. As a work of art, graphically delineating the configuration of a district of surpassing beauty and variety of scenery, it will, perhaps, possess greater interest to the ordinary observer than any scientific value of accuracy and completeness could give it. If a person were called upon to construct an ideal map which should group together specimens of all types of topographical form and the conventional signs known to the draughtsman, he could hardly derive from his imagination a chart more comprehensive than this. There is certainly nowhere else in our country an area of equal extent so diversified and broken. Extending from latitude 38° 45′ to 39° 32′, and from longitude 119° 33′ to 120° 22′, it reaches from the desert inland basin of Nevada to the timbered and grassy mountain-spurs—embraced by the multitudinous forks of the American River—with which the Sierra Nevada range descends into the Sacramento Valley of California.

Lake Tahoe is a sheet of water some ten by twenty miles in extent, situated high up in the heart of the Sierras. The mountain-range divides to receive the lake, forming a cup-like space in which its clear waters are gathered. On the map the lake is given the place of honor, in the center. Its surface, being six thousand two hundred feet above sea-level, is not far below the rim of mountains which inclose it, but which, however, slope to great depths in the Carson Valley on the east and toward the Pacific coast on the west. The range in altitude, from the lowest to the highest point on the map, is more than seven thousand feet, there being three mountains—Freel's Peak, Pyramid Peak, and Mount Rose—standing at three corners of the lake, which are upward of ten thousand feet in height. Thus the subject, taken as a whole, is an admirable one for cartographical expression and

effect, the surrounding valleys and the blank expanse of water in the center constituting a ground from which the mountains rise in bold relief.

Nor, taken in detail, is it less worthy of study. The agricultural district with its checker-work of farms, the great round hills which cover the Comstock lode, the barren edge of the desert, the sharp and ragged peaks which are the *sierras* proper, the easy grades of the forest-clad slopes about the lake, the rocky shore, the sandy beach, the angular course of the mountain-torrent as it dashes between cañon-walls, and its winding bed through the alluvial soil of the valley, are all given true to nature.

The draughtsman to whom this map owes its realistic appearance is Mr. John E. Weyss, a veteran of thirty years' continuous service as a topographer for our Government. In order to catch and preserve those characteristic traits of form and surface which it is so hard for one draughtsman to transmit to another, he visited the ground in person, and, from the summits of lofty peaks and other advantageous points, accumulated a series of sketches with the aid of which to restore a natural effect to the construction-plots of contour-lines as they came to his hands from the surveyors. The map is finished in hachures, a method which is more intelligible to the unprofessional eye than that of contours, and which, in this case, is made especially effective by a free and artistic handling of the subject. As that is the best map for popular use which, in its true proportions, presents the most exact picture of the country for which it stands, there is room, in a district accidented as this is, for many a felicitous touch and extra bit of shading not provided for in any of the schools of topographical drawing. In fact, the draughtsman who adheres too closely and conscientiously to Lehmann's or any other conventional diapason of shades is likely to construct a map whose geographical features are stiff, unnatural, and almost mechanical in their geometrical regularity, just as the writer who checks up every sentence by his text-books of grammar and rhetoric produces an essay with none but negative merits to recommend it.

Mr. Weyss accompanied General Michler, of the Engineer Corps, on his recent official mission to the different geodetic institutions of Europe, and, having seen the best that the Old World has to show, he still maintains that this is the finest geographical map ever made. Taking into consideration both the subject and the manner of its treatment, this claim is not an extravagant one. In one respect this has an advantage over the maps of the thickly settled European countries, upon which the utilitarian features of roads, villages, and other works of man are so numerous as to obscure the natural attractions of the land, and to give it the uninteresting appearance of a city plot; for too many right angles detract from the beauty of a map as well as from the charm of a landscape. While the advancing wave of civili-

zation has touched the region around Lake Tahoe, it has not yet covered it, and there are districts near its borders which are still as wild and secluded as in the days of the first explorer. There is the Devil's Basin, impassable and almost unapproachable, a great area of rock, rent with chasms and dotted with myriads of lakes. On every hand tower peaks upon whose summits, on a cloudy day, the traveler can feel as lonely as on the tops of the Alps or the Andes. And toward the northern limit of the map lies the historic Donner Lake, where, in the early days, a band of emigrants starved to death in the snows of winter.

But the practical pioneer is setting his seal upon this land, and claiming it as his own. Already the mountain-sides are marked with road, flume, ditch, and saw-mill, and scarred with mine and tunnel, and this lovely tract, fittest of all for a national park, is becoming the home of lumbermen and stock-raisers. The track of the plow is seen in the fertile valleys. The excavated ground of the Virginia City mines shows in the distance. Along the Carson River, at regular intervals, the quartz-mills lie. Log-slide, flume, and railroad carry the lumber from the heart of the forest to the outer world. The Pacific Railway winds between the high cañon-walls of the Truckee River and then follows its circuitous course, through miles of snow-shed and tunnel, across the Sierra Nevadas. Westward from Lake Tahoe runs the old Placerville road, once the main route of travel between California and Nevada, and down the eastern side of the range, in and out with many an escalop, winds the stage-road of the famous Hank Monk. From Virginia northward runs the Geiger Grade, the subject of one of Bret Harte's poems. In Emerald Bay is the little island with the empty grave which old Captain Dick carved for himself in the solid rock before he sunk in the deep water of the lake, to rise no more. Upon the cliff which bears the great poet's name the natural portrait of Shakespeare, done in weather-stain and lichen, is plainly visible. So there is enough of man's interference within the borders of this map to lend human interest and topographical variety to the scene.

It is a subject of common remark among travelers that nowhere else have they found a spot at once so easily reached and containing so great a variety of the interesting, the beautiful, and the grand, as here adjacent to Lake Tahoe, and this map will accomplish a not unimportant mission if it serves to call attention to a region too often overlooked. Leaving the Pacific Railway at Truckee or Reno, a circuit of one hundred miles will include not only this district, but the silver-mines of Virginia City and the mineral waters of Steamboat Springs as well. Then, from the south end of the lake, it is an easy *détour* of but a few miles to the crest of Tallac Peak, which, as if for the especial convenience of the tourist, is surrounded by an epitome of all types of Western scenery, from the placid beauty of Fallen-Leaf Lake, reposing at his feet, to the desolate wastes of rock which extend in chaotic piles behind him.

The map of Lake Tahoe was begun in the summer of 1876, in which season a survey of the shores of the lake and the mountains immediately outlying was made by Lieutenant M. M. Macomb, of the army, and the writer. Dr. F. Kampf, Mr. Gilbert Thompson, Lieutenant S. E. Tillman, Mr. William A. Cowles, Mr. Frank O. Maxson, Mr. Anton Karl, and other engineers have contributed to the work at different times. In one respect it is still incomplete, and it is to be hoped that provision may yet be made for a series of soundings with which to illustrate the very remarkable configuration of the bottom of the lake. It is scarcely to be doubted that the geographical map of the future, and especially the geological chart, will portray surfaces below as well as above water. These could be drawn in contour-lines, either faint, broken, or in blue color, so as to indicate their submarine position. The "ripple-lines" with which shores are now sometimes represented are arranged at regular intervals, in curves which are regularly concentric, and they give no idea of the additional character which a map would derive from a real plot of its surface below water.

Since the interest and effect of a plot increase with the irregularity of the surface of which it is a copy, no known body of water excels Lake Tahoe in the instruction to be gained from such a survey. It is very deep in comparison with its narrow superficial extent, the few random soundings already taken showing a depth of over sixteen hundred feet, with indications that there are other crater-like depressions beyond any yet discovered. The absence of currents and other subsurface agencies of disturbance has probably left the cliffs and cañons beneath the lake as rugged and unworn as those above it. The western bank is apparently abrupt and even precipitous, while the eastern shore is more gentle in its descent. Thus these declivities correspond to the two mountain-slopes of which they are respectively prolongations. A hydrographic survey would trace them in their descent, fathom the unknown depths to which they go, and furnish information which would not only be of general scientific and perhaps economical interest, but would also reveal the geological secret of the structure of this wonderful basin in the mountain-top.

NORTH AMERICA IN THE ICE PERIOD.

By C. H. HITCHCOCK,
PROFESSOR OF GEOLOGY IN DARTMOUTH COLLEGE.

FEW geological subjects have been discussed so much as the nature, extent, and cause of the glacial period. At first, the speculations of such men as Dr. Buckland upon the ice-markings excited derision, and led to the publication of caricatures. Next, when its claims

could not be set aside, some thought it the same with the flood of Noah, and others believed it to represent the chaos supposed to have pervaded space just before the advent of man. Then it was fashionable to believe in a submergence of the land by an ocean freighted with enormous icebergs, floating southerly from the pole. After this the battle raged fiercely between the advocates of icebergs and glaciers, the odds resulting in favor of the glacialists. Agassiz, with his polar-cap theory, advocated the view of a globe entirely encircled by ice, thickest at the poles, but covering the tropics with sufficient thickness to destroy the Tertiary life. Since these days of controversy, geologists have been accumulating facts in all glaciated countries; extreme views are being modified by their holders; and the time has come for consistent, reasonable generalizations in respect to the origin and extent of glacial phenomena.

Where the glacial markings have been most studiously investigated, it appears that an ice-sheet invariably occupies a definite area; that a *mer de glace* accumulates in the higher central portions, from which glaciers move outwardly in all directions, extending as far as the descending ground will permit, or the oceanic currents can convey the icebergs broken off from the frozen mass without melting; and that these ice-streams carry with them fragments of rock scoring the ledges as they pass along, thus affording the means for determining the exact dimensions of the glaciated areas, even after the climate has moderated and melted the ice. In Europe, the familiar Alpine district is constantly quoted as an illustration of the nature of a glaciated region, with its center of dispersion. Small ice-tributaries now cover the slopes of the Rhône Valley, where formerly the solid mass pressed down from the Bernese Oberland and the region of Mont Blanc, over Lake Geneva and the broad valley of Switzerland to the flanks of the Jura, forming an ice surface fifty miles wide, one hundred and fifty miles long, and two thousand feet deep. On the south, other streams have conveyed morainic materials equally far into the valley of the river Po. Hence we can assign to this area, with its center of dispersion, a definite number of square miles, linking together the actual glaciers with the traces of their former greater extension. No one will question the correctness of the generalizations enlarging the limits of the Alpine glaciated area.

We proceed next to consider the proper extent of the *Scandinavian district*, which will furnish an example more nearly analogous to that of Eastern America. Erdmann's map in Geikie's "Ice Age" represents striæ pushing northerly into the Arctic Ocean from Finland; southeast toward the White Sea and the Gulf of Finland; southerly in the south part of Sweden, turning to southwesterly toward the Cattegat; west, southwest, and northwest in Norway. Croll, in his work on "Climate and Time," supplements this map by drawing lines to indicate the direction taken by the ice after leaving Finland and

Scandinavia. The more eastern lines penetrate the edges of Russia and Prussia. Those passing into the Gulf of Bothnia and the Baltic Sea curve westerly so as to extend over the North Sea, English Channel, southern England, and the north of Scotland. England and Scotland are made to send off additional currents; and the limit of the ice-sheet reaches to west longitude 14°, or where the shallow water begins to deepen. The chart is designed to show the probable path of the ice in Northwestern Europe during the period of maximum glaciation. This area is about seventeen hundred miles wide and fifteen hundred from north to south, and will hence compare favorably in size with that of Eastern America. The phenomena of dispersion are explicable upon the theory of the origin of the current from the central Scandinavian ridge, supplemented by radial streams from the Scotch and Welsh highlands; and there is no evidence, unless upon the outermost Hebrides, of any flow of polar ice into the European district. The ice-masses have proceeded from higher to lower levels for the most part, rising somewhat to pass over Denmark and southern England; and there is no essential difference between the Alpine and Scandinavian areas save in size.

All the glaciated districts can now be referred to definite areas, separate from one another, and exhibiting grooves radiating from central points and lines. They are, first, the small Alpine district; second, the Scandinavian, with the British additions; third, the paleocrystic sea of the polar regions; fourth, Greenland; fifth, Eastern America, concerning which more will be said in the sequel; sixth, the Rocky Mountain areas, in which there were several groups of glaciers, confluent north of the Columbia River.

Maps will show how the several glaciated regions stand related to one another. They are isolated, disconnected, though all situated upon one hemisphere. Each was a center by itself. The ice moving from the central highlands made its way radially in all directions, carrying detritus and scouring the ledges. The larger ones do not vary greatly in their territorial dimensions. That of Eastern America exceeds the others, especially if we add to it the Arctic archipelago, where, owing to the high latitude, the *mer de glace* is nearly universal with no great amount of motion. But we do not discover from this delineation any confirmation of the notion of a general polar ice-cap, which has furnished the ice for both the European and American glacial sheets. The Scandinavian, Greenland, and American regions seem to have been entirely independent of each other—separated by deep ocean-water. All of them must have undergone their intense frigid conditions in post-Tertiary times, because of some astronomical cause affecting the northern hemisphere equally throughout. We do not find distinct glaciated areas upon the Asiatic side of the pole, because the relations of land and water are unfavorable to the formation of ice-sheets, but the temperature is and has been low enough.

We know but little respecting the ice-sheet about the pole. It has been fashionable to speak of an open polar sea, but no one has yet penetrated into it. The impression derived from the latest Arctic voyages of the American, English, Austrian, and Swedish expeditions is unfavorable to the existence of permanent open water. Yet there may not be an accumulation of a thick, frozen sheet, as the ice-rafts floating away from this northern waste are floes rather than bergs. Nares concludes that this ice is of great antiquity—that it is a paleocrystic rather than an open sea. We need additional observations to satisfy us that the climate is not more severe at the pole than on either side, and whether the meteorological dogma of two poles of cold is correct.

GREENLAND.—The study of the Greenland glaciers takes us a step further toward the understanding of the American ice-sheet. We have hardly appreciated the size of this island—it being larger than the Alpine glaciated tract. It is over twelve hundred miles long, and four hundred broad, or as far as from Boston to the Missouri River. The interior is covered by a field of ice never crossed in a direct line by any civilized being. From three points attempts have been made to learn something of its nature. In 1830 Keilsen went eighty miles inland from Holsteinberg—latitude 67°—reaching the edge of the ice-sheet, which could not be climbed. In 1870 Nordenskiöld went in a distance of thirty miles, reaching the altitude of twenty-two hundred feet. He observed that the ice rose gradually toward the interior. The outer edge is a high, precipitous wall. Once entered upon the broad surface of the ice, it is like traveling upon the sea, away from all sight of land. From north Greenland, Dr. Hayes penetrated to a distance of seventy miles. It was a day's journey from the sea to the wall of ice. The second day was spent in climbing to the table-land; the third day allowed a progress of thirty miles, the angle of ascent falling from six to two degrees. On the fourth day an altitude of five thousand feet was attained, and the ice still continued to rise, but, because of inclement weather, no further progress was practicable. The view was that of a frozen Sahara, immeasurable to the human eye.

It is probable that Greenland slopes westerly in general, having its main axis of elevation near the eastern border. It may be compared to a broad platter inclined westerly, with occasional chinks in the sides through which the ice discharges itself as if it were a viscous body. The principal discharge of icebergs is upon the western side into Baffin's Bay. Not less than thirteen glaciers are found upon the western side to the south of Upernavik, about 73° north latitude, and the largest ones occur farther north. Some of the bergs are three thousand feet thick. The Humboldt glacier empties into Smith's Sound with a width of sixty miles, and showing ice-cliffs from fifty to three hundred feet high above the water. The rock-cliffs adjoining are

from five hundred to one thousand feet high. At Polaris Bay a northward transportation is indicated, where Dr. Bessel found numerous granitic blocks containing peculiar garnets, such as abound in south Greenland, resting upon silurian limestones. Other glaciers have been mentioned farther north. Some have suggested that a series of islands will be found underneath the ice. Little is known of the eastern side, because it is practically inaccessible.

The general trend of Greenland is northwesterly. Hence the south end is farther east than any part of the western coast-line. The oversight of this simple fact has led to confusion among historians and statesmen. The island was discovered by Gunnibjörn in 872. In 983 Eric the Red, banished from Iceland, established a colony near the south end of Greenland, on its western shore, and gave to the island its name. The settlement prospered, and the indications of civilization left behind by these Norsemen exist as far north as Upernavik, or as far as the stoutest ships of modern times can sail without encountering serious risk. The population increased sufficiently to require the services of a bishop, and a list of seventeen terms of clerical office, from 1126 to 1406, has been preserved. A change of political relations led to the destruction of the commerce between Greenland and Scandinavia. Deserted by their friends, pirates and the Skraellings, or Esquimaux, completely exterminated the inhabitants. A record has been preserved in the Icelandic annals of the murder of the very last family in the fifteenth century. For some reason the Danes misunderstood the history after the removal of the restrictions upon the commerce, and many expeditions are said to have been sent out by the Government in search of their old colony in east Greenland, looking for it upon the coast facing Iceland rather than Baffin's Bay. It was thought that the descendants of the original settlers might still be found there, though for many years shut out from communication with Europe; but every ship returned baffled in its attempt to reach the eastern coast. Modern antiquarians have discovered the buildings erected by the Norsemen, read the inscriptions upon the churches and tombstones, and, by a study of the Icelandic sagas, deciphered the whole history, of which an outline has been already given. The facts have also been brought out prominently by Dr. Hayes in a small book describing some recent summer experiences in Greenland with a party of tourists.

All the Greenland glaciers become confluent in the interior, so that it is not a typical *mer de glace*, but a sheet of ice, which overspreads the highest mountains. It is only near the edge that the several streams manifest their independent existence. Thence the usual phenomena of Alpine glaciers manifest themselves. The sub-glacial streams pouring into the sea produce certain peculiarities. Immense supplies of heat penetrate the ice from the sun's rays, which melt very much ice and discharge muddy torrents of great size. As all water

seeks the lowest levels attainable, these currents will find a place at the bottom of the ice-sheet, and wear away the ground-moraines and other *débris*. Hence banks of earth or clay will be found continuous from the ice-cliff to as great a distance toward deep water as the currents have power to transport the material. Marine animals live in and upon these banks, and leave their remains in them. Hence the deposit is analogous to that series of marine clays called Champlain by me in 1861, and occurring so plentifully up to three hundred feet in the St. Lawrence Valley, and to one hundred and sixty feet along the coast of northern New England and the Provinces. It is obvious that they were contemporaneous with the glacial moraines upon the land, and not entirely consecutive, as so many have supposed. This was the position assumed by the late Professor Agassiz, and confirmed by our own published observations in the "Geology of New Hampshire," describing the occurrence of fossiliferous beds between the lower and upper till of Portland, Maine.

THE EASTERN AMERICAN ICE AREA.—The latest generalizations indicate that some part of the Labrador Peninsula may be considered as the center from which the ice has radiated over the Dominion of Canada and the northern United States east of the Rocky Mountains. By regarding the Greenland and polar areas as independent of the Labrador sheet, though possibly confluent at the time of maximum glaciation, a multitude of difficulties are removed, and our American glaciers are seen to have been subjected to the same laws as the several ice-fields of other parts of the world. This area extends from Baffin's Bay to Dakota, and from Hudson's Bay, or the Arctic Archipelago, to a line drawn from the Great Banks of Newfoundland through New Jersey, southern Ohio, etc., to the plains east of the Rocky Mountains.

Most of this territory exhibits a southwesterly course of glaciation. This is well shown over the highlands between Hudson's Bay and the St. Lawrence Valley, the valley itself, western New York, Ohio, Iowa, Minnesota, Manitoba, and so on to the extreme western limits. It is very prominent from Lake Superior, near the international boundary, westward to the Rocky Mountains. In eastern New York and the Champlain and Hudson Valleys the course is southerly. In New England the dominant direction is southeasterly, and the same is true of New Brunswick and Nova Scotia. The exceptional deviations are due to local influences, exerted in the decline of the age. The facts in hand for Newfoundland are too few for a satisfactory delineation, while not in disagreement with these generalizations. On the east coast of Labrador there are several fiords, as if there had been an ice-sheet upon the upper part of the peninsula, moving northeast and east. Professor O. M. Lieber's sketches in the Coast Survey report suggest a local glaciation, and not such a general smoothing as would be manifested in case the ice had come from the opposite Greenland coast.

Packard describes glacial markings in the Hamilton Inlet fiord running to the northeast, and thinks that the movement was to the southeast on the southern coast, or toward Newfoundland.

Farther north, the *Meta incognita* just north of Hudson's Straits shows an extensive *mer de glace*, with southerly-moving glaciers. McClintock describes bowlders at Leopold Harbor (North Somerset) and at Graham Moore Bay (Bathurst Island); which have been transported one hundred and one hundred and ninety miles northeast and northwest. Glaciated conditions are mentioned by various explorers to the west of Hudson's Bay, but we have no facts to indicate the direction of the movement. Several statements made in Franklin's second voyage imply a westerly movement.

There is a marked difference in the distances to which bowlders hsve been transported by the southwest and southeast currents. The average distance of the transportation in New England is from twelve to fifteen miles, and no bowlders, so far as known, have been carried more than one hundred miles. At the extreme north edge of Maine, as well as near the north line of Vermont, west of the Connecticut water-shed, are a few bowlders that have come from beyond the St. Lawrence, thus indicating a southeast movement across the St. Lawrence Valley, at right angles to what is supposed to be the common course. In Ohio many stones have been transported more than one hundred miles. In Iowa and Wisconsin bowlders of native copper occur from three hundred to four hundred and sixty-five miles away from their supposed source in Michigan. From the Lake of the Woods G. M. Dawson has described a transportation toward the Rocky Mountains of seven hundred miles. At Baton Rouge, Louisiana, are fossils, perhaps transported by floating ice, that seem to have come from Canada West, as much as twelve hundred miles ; and at Natchez, Mississippi, there has been found auriferous quartz, supposed to have come from Montana, eighteen hundred miles. The southwest direction has therefore afforded the examples of the greatest distance traveled by the bowlders. Perhaps topography has aided the result, and the St. Lawrence valley is directly continuous with the Western prairies and Mississippi bottoms, and the New England mountains have intercepted the material brought from the Laurentian highlands.

The evidence is clear, however, of the passage of the ice-sheet directly over all the higher New England summits in a southeasterly direction. The facts illustrative have been specifically given for the Green Mountains, as Mounts Mansfield, Camel's Hump, Pico, Eolus, etc. ; for Greylock, the highest of the Massachusetts mountains ; for Mount Washington, and others of the White Mountains, in New Hampshire ; and for Katahdin, in Maine, in the several geological reports of those States. The most important case is that of Mount Washington, both because of its greater altitude and because it has been generally supposed to have been an exception to the rule, and most geologists

have spoken of it as an island in the ice age.* I have fully stated elsewhere† the facts proving the presence of the ice-sheet there. They are, briefly, the usual glaciated appearance of the ledges, striæ, and transported bowlders, two of them weighing nearly one hundred pounds, and distinctly identical with ledges several miles distant. All the surface rocks above five thousand feet have been riven into angular fragments by the long-continued action of frost, insomuch that the embossment and striation have been nearly obliterated, and the fragments so covered by lichens that extraordinary care is required to discover any dissimilarity among them. Washington is the highest peak southeast from the St. Lawrence Valley; hence, if that has been glaciated by ice moving from the northwest, then every part of New England has been covered by the same sheet.

Assuming it well established that the center of dispersion for the Eastern American drift was in the west part of Labrador, we are met by the difficulty that the land beneath this central *mer de glace* is not so much elevated as the New England mountains which have been covered by the ice originating in those Laurentian highlands. As to the facts, they are indisputable—the glacier has moved over slopes higher than the mountains at its source; and it may be that we have something new to learn from these facts about ice accumulation and movement. Professor Dana has proposed the theory of a change of level in the land since the ice period. Assuming the starting-point to have been in the Laurentian highlands, if a descent of ten feet per mile be allowed, the sheet must have been at least thirteen thousand feet high to have allowed it to slide over Mount Washington; or, the land must have been four thousand five hundred feet higher than now.‡ The distance from these highlands to the base of the Rocky Mountains along which the ice is known to have moved southwesterly is about fifteen hundred miles, requiring, on the basis of Professor Dana's data, an elevation of certainly four miles. A change of level to that extent seems improbable.

Recent writers have developed a molecular theory of glacier motion; and in connection with it mention such possibilities of ice-accumulation as to suggest a method of relief from the difficulty of understanding how the ice can move up an elevation. The mere weight of the ice does not cause it to slide downward. According to Canon Moseley, from thirty to forty times its weight is required to shear the ice; the motion is proportional to the amount of heat present. The melted ice is very susceptible to the action of gravity, and the motion is greatest where the most heat is manifested, or upon the south side of the glacier.

* E. Hitchcock, "Proceedings of the American Association of Geologists," 1841, p. 182. L. Agassiz, "Geological Sketches," Second Series, p. 98.

† "Geology of New Hampshire," vol. iii, p. 203.

‡ "American Journal of Science," III, vol. ii, p. 327.

The writings of Moseley and Croll recall the utterances of Agassiz as respects the motion of the glacier. He himself modestly avows his physical researches upon the glacier as inferior to those of his successors, Forbes, Tyndall, etc.; yet he could not shut his eyes to the fact that those physicists had not satisfactorily solved the problem. While ascribing the motion to expansion by freezing, Agassiz insisted that heat was largely concerned, asserting that its presence was more consequential than that there should be an inclined plane—that the ice might move up-hill toward the sun; and particularly that a great thickness of it could make its way over such level territory as the prairies of Indiana and Illinois. The ice along the southern melting edge would be charged with moisture percolating through the pores and capillaries, descending the icy slopes obedient to gravity, and no longer requiring the shearing force. The amount of motion would in these circumstances be like that of the Greenland sheet, sixty feet per diem, rather than the sluggish crawl of one to three feet in the same time of the comparatively poorly developed Alpine glaciers. In agreement with these views we find the motion northward toward the pole to be very slight, though the land may be inclined northerly as in Grinnell Land.

Now, if we apply these principles to the territory in question, we would say that the ice began to accumulate in Canada from an unusual precipitation of moisture, gradually filling up the St. Lawrence Valley, and at first moving southwesterly. But, the supply still continuing plentiful, the valley fills up and runs over. It does not need to accumulate to the thickness of several miles upon the Laurentian highlands so as to have a downward slope all the way to Mount Washington. A mass only a few thousands—possibly hundreds—of feet thick might soften before the southern sun and the influence of the Atlantic Ocean off our coast, and lead the plastic material southeasterly over the Montalban water-shed. Once started upon the seaward slope, the ice could not fail to reach its destination. The southwest motion would likewise continue, and accomplish greater results, transporting blocks much farther because commencing earlier, continuing longer, and pushing forward in a thicker sheet. This Canadian ice would have resembled the present *mer de glace* of Greenland, confluent over hill, valley, and island, dragging the reluctant erratics up hill and down, accumulating ground moraines and lenticular hills, hollowing out pot-holes and discharging clouds of mud into the edge of the sea. Hence, instead of saying that the land rose three or four miles above its present level in Labrador in order to give the required impetus to the ice-movement in New England, it is easy to see how the same work could be accomplished by the action of much simpler causes.

Messrs. Torell and Dana have advocated the notion that the Greenland and Eastern American areas are one, and that Greenland was the source of the ice that has covered the eastern part of our continent.

One can not see that this view better suits the facts than to suppose there were two centers of dispersion, one for Greenland and the other for the continent. From Greenland to the southwest edge of the glaciated area the distance is twenty-five hundred miles, two fifths greater than from the Laurentian highlands, and requiring a descent of over seven miles of vertical elevation from the center to the circumference. It seems unnecessary to add to the difficulties of height incurred in the shorter distance. Provided there has been no great elevation of the land, Davis' Strait seems to contain enough ocean-water to carry off all the glacial products poured into it from either side. The facts of ice-movement already stated for Labrador and the Arctic Archipelago show motion easterly and northerly in the teeth of this imagined current from Greenland. Hence, as we find phenomena of glaciation in agreement with our view of radial dispersion from Labrador, whose existence was unknown to Torell, it seems as if it were altogether unnecessary to look so far as Greenland for the source of the ice-flow.

Terminal Moraines.—Years ago, those who believed icebergs would explain glaciation triumphantly asked the glacialists, Where are the terminal moraines which must have accumulated at the lower edge of the great ice-sheet? It is very strange their existence was not suspected by the early glacialists; and, as we now show their lines of distribution upon our maps, we remove another obstacle to the acceptance of the glacial theory.

Writers now generally employ the word *till* to denominate the materials accumulated by the ice, including the moraines and bowlder clays. The ground-moraine is that form of the till least noticed in the examination of active glaciers, because situated in the nearly impenetrable abysses between ice and earth. In the continental glacier, where the surface had the unbroken white snow for its covering, this form of moraine accumulation must have been the most abundant. In middle New England the ground-moraine is developed into the *lenticular hill*—an oblong rounded hummock, sometimes two hundred feet high, mostly composed of lower till, with a trend corresponding to the direction of the ice-current in the neighborhood, varying from nearly southeast near Newburyport to south 10° west in the Connecticut Valley. This lower till is compact, sometimes clayey, full of small, scratched, far-traveled stones in a forced position, with the iron coloring matter in the ferrous or protoxide condition. The capping of the hill or upper till is loose, the fragments are rough, not far removed from their source, commonly lying naturally, and the color is yellowish red from the presence of ferric oxide. These characteristics suggest the derivation of the upper till from the materials held in the ice at the time of its melting; they falling promiscuously upon the surface of the ground-moraine, compacted by the great weight of the glacier.

The moraines regarded by us as terminal are in all respects like

the upper till, as would be expected, considering that the fragments in front of the glacier principally consist of extensive tracts of that deposit crowded into a small compass. In connection with it one often sees sloping plains of gravel and sand deposited by streams of melted ice acting upon the moraine, or, if the supply of water has been copious, the unstratified drift has all been modified. Some authors think the upper till is only the surface portion of the ground-moraine acted upon and oxidized by atmospheric agencies. If the difference in the angularity, roughness, and distance traveled of the stones is not sufficient to justify our definitions, then these writers must explain why our terminal moraines should show the oxidation throughout their whole mass, hundreds of feet thick, while the upper till is usually very thin, often no deeper than the roots of large trees.

There are two lines of terminal moraines more conformable to each other than to the extreme southern limit of the glacier. East of Cape Cod this line is supposed to have passed over the St. George's and Great Newfoundland Banks, while the icebergs carried *débris* from the land to unknown distances southerly over the Atlantic Ocean. The outermost series of terminal moraines commences upon the Island of Nantucket, and is traceable thence across Martha's Vineyard, Block, Long, and Staten Islands; whence, according to Professor Cook, "the whole line of the moraine [across New Jersey] is remarkably plain and well defined." The line across Pennsylvania has been traced out recently by Mr. H. C. Lewis. This whole series, as far west as Ohio, occupies the outer margin of the glaciated area; and Professor Cook thinks the same moraines will be found conterminous with the extreme southern limit of the ice-sheet to its remotest bound in Montana.

The inner line of moraines starts at the middle of the east coast of Cape Cod, follows the curved shore to old Plymouth, thence south to the Elizabeth Islands on the border of Buzzard's Bay. After passing under water for several miles, it comes to the surface along the south shore of Rhode Island west of Narragansett Bay, touches Plum and Fisher's Islands, continues to the northeast angle of Long Island, passes through the greater part of Brookhaven, Riverhead, and Southold, where it disappears.

The outer moraine determines the topography of Long Island, as it constitutes a marked ridge, or "backbone," as sometimes called, from Montauk Point to Fort Hamilton. The highest point is three hundred and eighty-four feet, and the base of the moraines is usually more than fifty feet above tide-water. The southern slope is a gently inclined sandy plain, made of the ruins of the terminals; the northern slope terminates in cliffs, because so largely consisting of cretaceous clays. The eastern and middle portions of this ridge consist of modified drift, containing few or rare bowlders. The western portions represent the typical constitution of terminal moraines, and are well

shown in the numerous excavations made for building purposes about Brooklyn. The bowlders upon Long Island have all been brought from the northwest, and those familiar with the ledges in Connecticut and up the Hudson can readily recognize the fragments in the various parts of the island—the Palisade traps in Brooklyn, and the New Haven red sandstones to the southeast of their place upon the mainland.

We can recognize the inner moraine in Ohio, while its remnants may be found in New York State by future investigators. Dr. Newberry describes a line of kames occupying the water-shed between the affluents of the Ohio and Lake Erie, which can be easily correlated with the modified drift fringing our terminal moraine. This line extends entirely through Ohio, and bends sharply at Fort Wayne, Indiana, following St. Joseph's River northeasterly, so that its whole course is parallel to the shore of Lake Erie. N. H. Winchell thinks there are several of these moraines in the northwest part of Ohio. Professor T. C. Chamberlin has generalized the facts about the course of these moraines between Pennsylvania and Minnesota, and supposes there are two morainic lines parallel to the shore of Lake Erie, the outer reaching to middle Indiana. Likewise there appear moraines in the form of loops following the course of the shores of Lake Michigan, Green Bay, Keweenaw Bay, and the southwest end of Lake Superior. The glaciers seem to have followed the several valleys, continuing to flow as long as the material lasted. The Green Bay and Lake Superior streams did not cover the area in the lee of the highlands of northern Wisconsin; and hence there was a large tract of land, occupying essentially what is known as the "Lead-region of the Northwest," over which we search in vain for erratics or glaciated surfaces. Mr. Warren Upham has communicated to us many facts for Minnesota, Dakota, and Iowa. They indicate two looped moraines west of the Mississippi: one reaching nearly to Yankton, Dakota, having the celebrated *Coteau de Missouri* for its western border, and part of the *Coteau de Prairie* for its eastern; the other taking the eastern line of the *Coteau de Prairie* for one side, and pointing east of south to Des Moines, Iowa. An inner loop connecting the Wisconsin moraine with that of the Leaf Hills may have been pushed there by the Lake Superior stream, and the more southern loops may have had some connection with glaciers starting in the Dominion portions of the Rocky Mountains. Hence the Labrador and Rocky Mountain sheets may have been confluent, and, owing to the great masses of ice thus accumulated along the upper part of the tributaries of the Mississippi basin, we may understand why the glacier extended so much farther south in the interior than upon either coast.

Elevation of the Land in the Glacial Age.—The earlier writers accounted for the glacial cold by supposing the land had been elevated sufficiently to lower the temperature, and subsequently de-

pressed to its original level. Later authors suggest that the formation of ice-caps at the poles would draw away enough water from the lower latitudes to increase the amount of land in the north. Either view would afford conditions adequate to produce the results; but the evidences of such an oscillation, from the nature of the case, are very difficult to obtain. The most obvious are derived from the existence of ancient river-channels now submerged beneath the ocean. Upon the south sides of Long Island* and Cape Cod† there are several ravines channeled out of the till and modified drift, too large to have been excavated by the present drainage system. They are fiords, and many of them are filled by linear fresh-water lakes, kept in position by bars of beach-sand near the ocean's level. Similar facts have been reported in connection with the former entrances of tributary streams into the Great Lakes.‡ In all these cases the excavations must have been made in connection with the disappearance of the ice-sheet.

A more extensive series of excavations occurred in the larger rivers, though it is not so easy to fix their date. By studying the submarine contours off the mouths of the Connecticut and Hudson Rivers, we can follow the outlines of their valleys for many miles out to sea. The first named flowed around the east end of Long Island, leaving the Housatonic to join the Hudson just below Manhattan Island, as shown by Professor Newberry. The Hudson continued southerly for seventy or eighty miles, as first pointed out by Professor Dana. As no deltas appear in connection with the present mouths of these streams, their submergence must have been comparatively recent, while they may have existed as channels of erosion for millions of years.

A further examination of coast-charts reveals the fact that there is a belt of shallow land bordering the continent from New Jersey to Newfoundland, and that it is as wide as the extensions of the Hudson and Connecticut. Hence, if there has been a submergence off New York, the same oscillation occurred along the whole coast; and thus a tract of land, as large as Pennsylvania, New York, and the maritime provinces combined, has been lost to the continent, probably since the glacial period. The corresponding area in Northern Europe, which seems to have been elevated at the same time, may be found indicated in Geikie's "Ice Age."

More impressive proofs of a former elevation of the continent appear from a careful study of the lower Mississippi. The contour-line of one thousand feet depth suggests the continuance of the river-bed for a distance of forty miles into the Gulf of Mexico. The Tertiary rocks of the river-basin have been excavated to the depth of two

* "American Journal of Science," III, vol. xiii, p. 142 (Lewis).

† "American Naturalist," vol. xiii, p. 555 (Upham).

‡ The discovery of the pre-glacial outlet of Lake Erie by Professor J. W. Spencer, and the former northerly drainage of the tributaries of the Alleghany River by the Pennsylvania geologists, have been published since this article was written.

hundred to five hundred feet, and then unconformably overlaid by the orange sand—a deposit coeval with the glacial drift. Borings in lower Louisiana show first the Port Hudson group or post-glacial deposits; second, the orange sand; and, third, the underlying eroded Tertiaries with their characteristic fossils. This excavation could not have been made unless the waters of the Gulf had been at least five hundred feet lower than at present.

Other facts further illustrate these former elevations. Upon the Atlantic border between New Orleans and New York we find a low, broad plain, largely consisting of marshy or drowned lands. On reaching Virginia this land begins to disappear, but the plain holds the same relation to the continent, as it continues to exist in the submarine banks east of Massachusetts. Curiously enough, we now dredge from the George's and Great Banks Tertiary fossils similar to those occurring in the unsubmerged parts of this plain. Their existence beneath the ocean had never been suspected till the possible identity of the Atlantic plain with the eastern shoals had been suggested, subject to the crucial test of dredging.

These facts authorize us to believe that the eastern half of the continent has been elevated certainly six hundred feet in the glacial period. As this elevation included Northern Europe, and consequently the polar districts, so as to unite the Old and the New Worlds, we may be able to follow the older writers, and find in this land-mass the conditions adequate to produce the glacial cold. Such a cause will explain the facts more satisfactorily than the invocation of the eccentricity of the earth's orbit, or the precession of the equinoxes. If we can combine the two classes of causes, we can certainly explain all the phenomena, besides obtaining the data for the chronology of the ice age.

The Melting of the Glacial Sheet.—Time fails us to describe the marvelous facts connected with the melting of the ice. The numerous kames, elevated sand-plains, and river-terraces, found everywhere in Northern America, came into existence with the copious floods of water resulting from the dissolution of the ice. The history of the ice age is incomplete without a discussion of the events occurring in this great continental freshet; but this sketch must be deferred for the present.

AN EXPERIENCE IN SCIENCE-TEACHING.

By STANLEY M. WARD.

FOR the past two years I have had charge of a public school in Pennsylvania, and have endeavored to awaken in the minds of my pupils a love for and an interest in science, with especial reference to the truths and lessons of physiology and zoölogy. Perhaps my

experience may not prove valueless or uninteresting to teachers and others.

The summer of 1878 was spent at Salem, at the Summer School of Biology connected with the Peabody Academy of Science, and, while there, the ideas on teaching gathered from Huxley, Mill, Bain, and Spencer, took a tangible shape; and I determined that classes in physiology that came under my charge should have the benefit of practical work so far as lay in my power to give it. In September of that year I organized a class in physiology, made up of young ladies and gentlemen between the ages of sixteen and twenty-one. With this material I went to work. My plan was briefly this: Teach as many facts in this study and those connected with it as possible; then for direct use have the pupils get some idea, if but slight, of the progress of science, and develop mental discipline by pursuing the work according to the scientific method, so far as time and material will permit. To accomplish these results seemed to be worth striving for; and, without making any pretensions to exhaustive work, I followed a programme substantially as follows: A suitable text was provided, and, with this in hand and a human skeleton, we considered the location, use, form, structure, articulation, etc., of the bones; the same was done with many of the muscles, being aided in this by an excellent series of plates; the skin next claimed attention, and in succession followed the circulatory, respiratory, and digestive systems. During this time there were no regular recitations, but each scholar was free to ask any question on the preceding lesson to any member of the class he saw fit; in this way we took a cursory view of the human frame outside of the nervous and reproductive systems. After we had seen something of the mechanism in its entirety, and had a general idea of it, I chloroformed a cat and dissected it before the class; this was not performed in my regular school-room, but in a small room off, which had been used for recitations by one of my teachers. During the operation the class asked questions, and were at perfect liberty to discuss any topic connected with the subject, or to ask explanations concerning the structure or use of any part examined. The dissection did not aim to be exhaustive, the idea being more to clinch the facts which had before been given, and to present in a clearer light the form of the body interiorly. After this dissection the class recited from the text, and were aided with plates, specimens, and informal talks, through the whole course. After finishing the work another animal was procured, and several members of the class took turns in dissecting, sometimes several working at once and sometimes one only; here I endeavored to give the pupils their own way, the object being not to make skilled dissections, but to teach them to study nature at first hand. In this work they followed Foster and Langley as closely as possible. We then made a thorough review of the whole text, this work being supplemented by bringing

before the class a few birds, some insects, a fish, some frogs, and a few tadpoles. The remainder of the term was spent in studying comparative physiology and anatomy. I followed out this course, with few modifications, with a number of classes, and never failed to interest them. There was but little attention paid to the nervous system, as I considered it too abstruse for the students. I will say, however, that, after spending some little time on the brain and spinal column of a cat and dog, a few of the pupils of their own accord worked out the nervous system of a crawfish in quite an admirable manner. The work done was, of course, far from thorough, and will bear no comparison to that performed in more pretentious institutions: it will be remembered that I was working under a school system which does not require physiology to be taught, that I had nothing to work with except what I myself furnished, and that, worse than all, I had a tremendous prejudice to combat.

Whether I was successful or not may be judged by the fact that some members of the class who went over the ground in this way now occupy their spare time in summer in making collections of the flora and fauna in their vicinity. I further noticed that in Latin and mathematics those pupils who were most interested in physiology were quicker and clearer observers, more accurate reasoners, and more just and keen in their criticisms, than those of equal caliber who had not taken the course.

I give this experience for what it is worth, hoping that, if it meets the eye of one teacher who has a class in physiology, and is teaching by the old method of exclusiveness, he will try the process above described (which is far from original), confident that he will meet with success beyond his most sanguine expectations.

DISEASE-GERMS.

By Dr. WILLIAM B. CARPENTER.

AMONG the distinguished men who came together at the recent International Medical Congress—a gathering altogether unexampled for its combination of great and varied ability, and worthily representative of almost every country in which medicine is studied—there was no one whose presence was more universally or more cordially welcomed than a quiet-looking Frenchman, who is neither a great physician nor a great surgeon nor even a great physiologist, but who, originally a chemist, has done more for medical science than any *savant* of his day; and this, not only (probably not so much) through the results already attained by Pasteur himself and by others working on his ideas—great though these results are—but through the entirely

new direction he has given to scientific inquiry, the number of new paths of research he has opened out, and of new clews he has afforded to those who will follow them up, and, last but by no means least, by the admirable example he has afforded, in the strictness and severity of his own methods (which have made him almost unerring in his predictions, and have given his conclusions the force of demonstrations), to those who would carry on the same lines of inquiry.

And here I would stop to note, as honorable to the disinterested character of a profession which has been lately the object of violent abuse for its (alleged) selfish and mercenary spirit, that this unique welcome was given, not to a great physician who had discovered a cure for gout, cancer, or consumption, by the use of which it would be enriched—not to a bold surgeon who had brought into vogue some wonderful operation, the success of which would tend to its renown—but to the scientific investigator of the *causes* of disease, whose work belongs altogether to the domain of *preventive* medicine, and thus, so far from being likely to benefit its members pecuniarily, tends only to diminish their remunerative employment. I never felt so proud of belonging to the body which still does me the honor to recognize me as one of its members as I did when Sir James Paget, the President of the Congress, paused in his opening address to point out on the platform behind him the greatest living exemplar of the truths he was so admirably enforcing, and when the whole of his vast audience—the like of which had never before been gathered in St. James's Hall, and perhaps never will be again—enthusiastically cheered, not once only, but again and again, the scientific veteran whose renown has spread from his quiet Parisian laboratory over the whole civilized world.

In order that the last of Pasteur's great achievements—which, with some of the ideas it suggests, it is my object now to bring before the readers of "The Nineteenth Century"—may be properly appreciated, it will be well for me to sketch out briefly what has been the nature of his life-work from the time when the singular beauty of some of his chemico-physical researches (which obtained for him in 1856 the Rumford Medal of the Royal Society) marked him out as one likely to attain further distinction.

It seems to have been by his special interest in the chemistry of organic substances that he was early led to examine into the question of fermentation, which had come to present an entirely new aspect through the discovery of Cagniard de la Tour that yeast is really a *plant* belonging to one of the lowest types of fungi, which grows and reproduces itself in the fermentable fluid, and whose vegetative action is presumably the cause of that fermentation, just as the development of mold in a jam-pot occasions a like change in the upper stratum of the jam, on whose surface and at whose expense it lives and reproduces itself. Chemists generally—especially Liebig, who

had a fermentation-theory of his own—pooh-poohed this idea altogether; maintaining the presence of the yeast-plant to be a mere concomitant, and refusing to believe that it had any real share in the process. But, in 1843, Professor Helmholtz, then a young, undistinguished man, devised a method of stopping the passage of organic germs from a fermenting into a fermentable liquid, without checking the passage of fluids; and, as no fermentation was then set up, he drew the inference that the "particulate" organic germs, not the soluble material of the yeast, furnish the *primum mobile* of this change—a doctrine which, though now universally accepted, had to fight its way for some time against the whole force of chemical authority.*

A little before Cagniard de la Tour's discovery, a set of investigations had been made by Schulze and Schwann to determine whether the exclusion of air was absolutely necessary to prevent the appearance of living organisms in decomposing fluids, or whether these fluids might be kept free from animal or vegetable life by such means as would presumably destroy any germs which the air admitted to them might bring in from without, such as passing it through a red-hot tube or strong sulphuric acid. These experiments, it should be said, had reference rather to the question of "spontaneous generation," or "abiogenesis," than to the cause of fermentation and decomposition, its object being to determine whether the living things found by the microscope in a decomposing liquid exposed to the air spring from germs brought by the atmosphere or are generated *de novo* in the act of decay—the latter doctrine having then many upholders. But the discovery of the real nature of yeast and the recognition of the part it plays in alcoholic fermentation gave an entirely new value to Schulze's and Schwann's results, suggesting that putrefactive and other kinds of decomposition may be really due, not (as formerly supposed) to the action of atmospheric oxygen upon unstable organic compounds, but to a new arrangement of elements brought about by the development of germinal particles deposited from the atmosphere.

It was at this point that Pasteur took up the inquiry, and, for its subsequent complete working-out, science is mainly indebted to him; for, although other investigators—notably Professor Tyndall—have confirmed and extended his conclusions by ingenious variations on his mode of research, they would be the first to acknowledge that all those main positions which have now gained universal acceptance—save on the part of a few obstinate "irreconcilables"—have been established by Pasteur's own labors. These positions may be briefly summarized as follows:

1. That no organic fluid undergoes *spontaneous* fermentation or

* It was, I remember, in or about that year that Professor Liebig's visit to England gave me the opportunity of showing him some yeast under a high power of the microscope. He said that he had not before seen its component cells so distinctly.

decomposition, even in the presence of atmospheric air, any such action being originated and maintained only by the developmental action of definite organic germs.

2. That different kinds of fermentation (using that term in its large sense) are produced by organic germs of different species. Thus, while *torula* sets going the alcoholic fermentation in a saccharine wort, other fungoid germs will set up the acetous, and others, again, the putrefactive fermentation, when introduced into fluids of the same kind.

3. That many different kinds of germs—notably those of the *bacteria*, which induce putrefactive fermentation—are constantly floating in the ordinary atmosphere, so as to be almost certainly self-sown in any organic fluid freely exposed to it.

4. That, if these germs be removed by mechanical filtration, or be got rid of by subsidence, or be deprived of their potency by chemical agents which destroy their vitality, the most readily decomposable organic fluid may be subjected to the freest contact with the air from which the germs have been thus eliminated without undergoing any change.

5. That, as there is no such thing as fermentation without the presence of germ-particles, so there is no such thing as the spontaneous origination of such germs, each kind, when sown in the liquid, reproducing itself with the same regularity as in higher plants, and thus continuously maintaining its own type.

6. That such germ-particles, when dried up, can not only maintain their germinal power for unlimited periods, starting into renewed activity so soon as the requisite conditions are supplied, but that, in this state of dormant vitality, they can be subjected to influences which would destroy the life of the growing plants—such as very high or very low temperatures, the action of strong acid or alkaline solutions, and the like.*

The first application of these doctrines to the study of disease in the living animal was made in a very important investigation, committed to Pasteur by his old master in chemistry (the eminent and eloquent Dumas), into the nature of the *pébrine*, which was threatening to extinguish the whole silk-culture of France and Italy. It had been previously ascertained that the bodies of the animals affected with this disease (whether in the worm, chrysalis, or moth stage) swarm with peculiar minute corpuscles, which even pass into the undeveloped eggs of the female moth, but there was no evidence that these corpuscles were independent, self-developing organisms introduced from without, many regarding their presence as a mere expression or concomitant of the disorder, not as its cause. It would be too long to detail the steps of this most complicated and difficult inquiry, and I must satisfy myself with the mere statement that it not only

* The evidence on which these conclusions rest is fully stated in Professor Tyndall's recently published treatise on the "Floating Matter of the Air."

proved completely successful as to what may be termed its commercial object, but that, though it concerned only a humble worm, it laid the foundation of an entirely new system and method of research into the nature and causes of a large class of diseases in man and the higher animals, of which we are now only beginning to see the important issues.

Among the most *immediately* productive of its results may be accounted the "antiseptic surgery" of Professor Lister, of which the principle is the careful exclusion of living bacteria and other germs alike from the natural internal cavities of the body and from such as are formed by disease, whenever these may be laid open by accident or may have to be opened surgically. This exclusion is effected by the judicious use of carbolic acid, which kills the germs without doing any mischief to the patient; and the saving of lives, of limbs, and of severe suffering, already brought about by this method, constitutes in itself a glorious triumph alike to the scientific elaborator of the germ-doctrine and to the scientific surgeon by whom it has been thus applied.

A far wider range of study, however, soon opened itself. The revival by Dr. Farr of the doctrine of *zymosis* (fermentation), long ago suggested by the sagacity of Robert Boyle, and practically taken up in the middle of the last century by Sir John Pringle (the most scientific physician of his time), as the expression of the effect produced in the blood by the introduction of a specific poison (such as that of small-pox, measles, scarlatina, cholera, typhus, etc.), had naturally directed the attention of thoughtful men to the question (often previously raised speculatively) whether these specific poisons are not really organic germs, each kind of which, a real *contagium vivum*, when sown in the circulating fluid, produces a definite *zymosis* of its own, in the course of which the poison is reproduced with large increase, exactly after the manner of yeast in a fermenting wort. Pasteur's success brought this question to the front as one not to talk about but to work at, the lead being taken, I believe, by M. Chauveau, the distinguished Professor of Medicine at Lyons, but other investigators (among them our own Professor Burdon-Sanderson) followed closely in his wake. Pasteur's own attention seems at that time to have been chiefly directed to what may be termed the pathology of beer, wine, and vinegar, and to the fight he had still to maintain with the advocates of abiogenesis. I shall not stop to describe the valuable improvements he has introduced into the manufacture of alcoholic and acetous liquors, with a view of preventing those injurious fermentations which often interfere with the normal processes, and sometimes ruin their results, but shall keep to the object I have specially in view, the exposition of those more recent contributions to "preventive medicine," which constitute him the greatest public benefactor of his time.

An epizoötic malady extensively prevails on the Continent of Europe, though fortunately but little known in this country, which is sometimes designated "splenic fever," and sometimes "anthrax" or "carbuncular" disease, while it is known in France as "charbon" or "pustule maligne." In its most malignant form, it causes the death of the horses, cattle, and sheep affected by it, in the course of four-and-twenty hours. In the less severe form of anthrax disease, it occasions great and prolonged suffering, even when final recovery takes place. Both forms seem propagable to man. Between the years 1867 and 1870, above 56,000 deaths from this disease are recorded as having occurred among horses, cattle, and sheep, and 528 deaths among the human population, in the single district of Novgorod in Russia. It appears to be scarcely ever absent from France, and is estimated to involve an annual loss of many millions of francs on the part of breeders in that country, whole flocks and herds being carried off at once, and their proprietors ruined. A mild epizoötic of this type seems to have prevailed in this country between 1850 and 1860; while the "plague of boils," under which many of our human population (my unhappy self among the rest) suffered during some part of that decennium, was probably brought on us by infection from animals. Attention has lately been drawn to a severe and often fatal malady occurring among the "wool-sorters" at Bradford, which is pretty certainly a modification of "splenic fever," communicated by the wool of sheep infected with that disease.

As far back as 1850 it was observed by two distinguished French pathologists, MM. Rayer and Davaine, that the blood of animals affected with splenic fever contained minute, transparent rods; but their fungoid nature and life-history were first worked-out a few years since by a young German physician named Koch, whose account of it was soon confirmed by Cohn, the eminent Botanical Professor of Breslau, and afterward in this country by Mr. Ewart, all of whom "cultivated" the plant in aqueous humor, or some other organic liquid of suitable character, kept at nearly blood-heat. They found the "rods" to be produced by progressive extension from germ-particles of extreme minuteness. At first they are simple tubes divided at intervals by transverse partitions, but after a time minute dots are seen within these tubes, which gradually enlarge into ovoid bodies that lie in rows within the rods, and at last the rods fall to pieces, liberating the germ-particles they included. The minutest drop of the fluid containing these germs, if conveyed into another portion of cultivated fluid, initiates the same process of growth and reproduction, and this may be repeated many times without any impairment of the potency of the germs, which, when introduced by inoculation into the bodies of rabbits, Guinea-pigs, and mice, develop in them all the characteristic phenomena of splenic fever. Koch further ascertained that the blood of animals that succumbed to this disease might be dried and kept for

four years, and might be even pulverized into dust, without losing its power of infection.

Here I would stop to cite the prophetic words used by Professor Tyndall, when giving an account to a Glasgow audience, in 1876, of Koch's then recent researches: "The very first step toward the extirpation of those contagia is the knowledge of their nature; and the knowledge brought to us by Dr. Koch will render as certain the stamping out of splenic fever as the stoppage of the plague of *pébrine* by the researches of Pasteur."

It was but fitting that the complete verification of this prediction should be the direct result of the labors of the illustrious man on whose previous work it was based, although others were at work, more or less successfully, in the same direction.

One of the first questions examined by Pasteur was the cause of outbreaks of "charbon" in its most deadly form among flocks of sheep feeding in what appeared to be the healthiest pastures, far removed from any obvious source of infection. Learning by the inquiries he instituted that special localities seemed haunted, at distant intervals, by this plague, he inquired what had been done with the bodies of the animals that had died of it, and learned that it had been customary to bury them deep in the soil, and that such interments had been made, it might have been ten years before, beneath the surface of some of the very pastures in which the fresh outbreaks took place. Notwithstanding that the depth (ten or twelve feet) at which the carcasses had been buried seemed to preclude the idea of the upward traveling of the poison-germs, the divining mind of Pasteur found in *earth-worms* a probable means of their conveyance, and he soon obtained an experimental verification of his idea, which satisfied even those who were at first disposed to ridicule it. Collecting a number of worms from these pastures, he made an extract of the contents of their alimentary canals, and found that the inoculation of rabbits and Guinea-pigs with this extract gave them the severest form of "charbon," due to the multiplication in their circulating current of the deadly *anthrax-bacillus*, with which their blood was found after death to be loaded.

Another mode in which the disease-germs of anthrax may be conveyed to herds of cattle widely separated from each other and from any ostensible source of infection was discovered by the inquiries prosecuted, a few years ago, by Professor Burdon-Sanderson at the Brown Institution, in consequence of a number of simultaneous outbreaks which occurred in different parts of the country. It was found that all the herds affected had been fed with brewers' grains supplied from a common source; and, on examining microscopically a sample of these grains, they were seen to be swarming with the deadly *bacillus*, which, when it has once found its way among them, grows and multiplies with extraordinary rapidity.

The next important step in this investigation was the discovery of the modification in the potency of the poison, which can be produced by the "cultivation" of this *bacillus*. Every one knows that some of our most valued esculent plants and fruits are the "cultured" varieties of types which man would scarcely care to use in their original state, on account of the unpleasantness of their flavor or their semi-poisonous qualities. And, now that we know that these disease-germs are really humble types of vegetation, the idea naturally suggests itself whether they, too, may not be so far modified, by the "environment" in the midst of which they are developed, as to undergo some analogous modification. Two modes of such "culture" suggest themselves: the introduction of the germs into the circulating current of animals of a different type, and its repeated transmission from one such animal to another; and cultivation carried on out of the living body, in fluids (such as blood-serum or meat-juice) which are found favorable to its growth, the temperature of the fluid in the latter case being kept up nearly to blood-heat. Both these methods have been used by Pasteur himself and by Professor Burdon-Sanderson; and the latter especially by M. Toussaint, of Toulouse, who, as well as Pasteur, has experimented also on another *bacillus* which he had found to be the disease-germ of a malady termed "fowl-cholera," which proves very fatal among poultry in France and Switzerland.* It has been by Pasteur that the conditions of the mitigation of the poison by culture have been most completely determined, so that the disease produced by the inoculation of his "cultivated" virus may be rendered so trivial as to be scarcely worth notice. His method consists in cultivating the bacillus in meat-juice or chicken broth, to which access of air is permitted while dust is excluded, and then allowing a certain time to elapse before it is made use of in inoculation experiments. If the period does not exceed two months, the potency of the *bacillus* seems but little diminished; but, if the interval be extended to three or four months, it is found that, though animals inoculated with the organism take the disease, they have it in a milder form, and a considerable proportion recover; while, if the time be still further prolonged, say to eight months, the disease produced by it is so mild as not to be at all serious, the inoculated animals speedily regaining perfect health and vigor.†

* I have seen notices of its serious prevalence during this very summer in some of the localities most frequented by tourists.

† It is not a little curious that as culture of one kind can mitigate the action of the poison-germs, so culture of another kind may restore, or even increase, their original potency. It has been found by Pasteur that this may be effected by inoculating with the mitigated virus a new-born Guinea-pig, to which it will prove fatal; then using its blood for the inoculation of a somewhat older animal; and repeating this process several times. In this way a most powerful virus may be obtained at will—a discovery not only practically valuable for experimental purposes, but of great scientific interest, as throwing light upon the mode in which mild types of other diseases may be converted into malignant.

Thus, then, it becomes possible to affect sheep and cattle with a form of anthrax-disease so mild as to bear much the same relation to the severer forms that cow-pox bears to small-pox; and for this artificial affection with the mitigated disorder, Pasteur uses the term "vaccination." The question that now arises—to which the whole previous investigation has led up—is the most important of all: Does this "vaccination" with the mild virus afford the same protection against the action of the severe, that is imparted by cow-pox vaccination against small-pox? To this question affirmative answers were last year obtained by Professor Greenfield (on Professor Burdon-Sanderson's suggestion) in regard to bovine animals, and by M. Toussaint in regard to sheep and dogs; the former, when "vaccinated" from rodents, and the latter from fluids "cultivated" outside the living body after a method devised by M. Toussaint, proving themselves incapable of being infected with any form of anthrax-disease, though repeatedly inoculated with the malignant virus, and remaining free from all disorder, either constitutional or local. The same result having been obtained from experiments made by Pasteur himself, probably about the same date, with charbon-virus cultivated in the manner previously described, it was deemed expedient by one of the Provincial Agricultural Societies of France that this important discovery should be publicly demonstrated on a great scale. Accordingly, a farm and a flock of fifty sheep having been placed at M. Pasteur's disposal, he "vaccinated" twenty-five of the flock (distinguished by a perforation of their ears) with the *mild* virus on the 3d of May last, and repeated the operation on the 17th of the same month. The animals all passed through a slight indisposition, but at the end of the month none of them were found to have lost either fat, appetite, or liveliness. On the 31st of that month, all the fifty sheep, without distinction, were inoculated with the *strongest* charbon-virus, and M. Pasteur predicted that on the following day the twenty-five sheep inoculated for the first time would all be dead, while those protected by previous "vaccination" with the mild virus would be perfectly free from even slight indisposition. A large assemblage of agricultural authorities, cavalry-officers, and veterinary surgeons having met at the field the next afternoon (June 1st), *the result was found to be exactly in accordance with M. Pasteur's predictions.* At two o'clock *twenty-three* of the "unprotected" sheep were dead; the *twenty-fourth* died within another hour, and the *twenty-fifth* an hour afterward. But the twenty-five "vaccinated" sheep were all *in perfectly good condition;* one of them, which had been designedly inoculated with an extra dose of the poison, having been slightly indisposed for a few hours, but having then recovered. The twenty-five carcasses were then buried in a selected spot, with a

By Dr. Grawitz, indeed, it has been recently asserted that even some of the most innocent of our domestic microphytes may be changed by artificial culture into disease-germs of deadly infectiveness.

view to the further experimental testing of the poisonous effect produced upon the grass which will grow over their graves. But the result, says the reporter of the "Times" (June 2d), "is already certain; and the agricultural public now know that an infallible preventive exists against the charbon-poison, which is neither costly nor difficult, as a single man can inoculate a thousand sheep in a day." I have since learned that this protection is being eagerly sought by the French owners of flocks and herds; and, if any severe epidemic of the same kind were to break out in this country, our own agriculturists would probably show themselves quite ready to avail themselves of it. To the "wool-sorters" of Bradford it must prove a most important boon, if they can be led to understand its value.

That this is not to remain an isolated fact, but will be the first of a series of discoveries of surpassing importance (some of them already approaching maturity), is shown by the fact that Pasteur has found himself able to impart a like protection against fowl-cholera by "vaccinating" chickens with its cultivated *bacillus*.

These wonderful results obviously hold out an almost sure hope of preventing the ravages, not merely of the destructive animal plagues that show themselves from time to time among us, but of doing that for some of the most fatal forms of human infectious disease which Jennerian vaccination has already done—as shown by Sir Thomas Watson in these pages—for what was once the most dreaded of them —small-pox. It is unfortunately too true that, with the reduction of small-pox mortality, there has been an increase in the mortality from measles and scarlatina exceeding that which increase of population would account for, the number of deaths in England and Wales from the former of these diseases frequently exceeding 10,000 in the year, while the annual mortality from the latter averages nearly 20,000, sometimes exceeding 30,000. It scarcely seems too much to expect that before long, as Professor Lister last year suggested, "an appropriate 'vaccine' may be discovered for measles, scarlet fever, and other acute specific diseases in the human subject"; for already, as I have been informed by one of the most distinguished of the United States members of our Congress, researches have been there made, with very promising results, on the "cultivation" of the *diphtheritic* virus—the mortality from which, in England and Wales, during the last decade, has averaged nearly 3,000 annually, being, for the seven years, 1873–'79, *half as great again* as the mortality from small-pox during the same period.

Another important line of inquiry, which was supposed by many able pathologists to have been closed by the negative results of previous investigations, has now to be reopened under the new light shed upon it by Pasteur's discoveries: I refer to the relation between cow-pox and small-pox. It is well known that Jenner himself, struck with the fact that the protective influence of successful vaccination against

the *oc*currence of small-pox is about the same as that of a first attack of small-pox against its *re*currence, suspected that cow-pox might really be small-pox modified by passing through the living body of the cow; and attempts have been made, at different times and in various places, to test the truth of this hypothesis. Before proceeding, however, to discuss that question, it will be advantageous to consider what new light is cast, by recent scientific discovery, on the *nature* of the protection afforded by successful vaccination.

Notwithstanding the "strong assurance of faith," on the part of Jenner and his immediate disciples, in regard to the permanent efficacy of vaccination, it is certain that, as time went on, a suspicion grew up among vaccinators of long experience, that vaccinia has a tendency to degenerate—i. e., to lose its protective power—in proportion to the remoteness of its derivation from the original (cow) stock. During my own early professional life (1830–'40) in Bristol, this conviction was prevalent among the older practitioners, who recollected the early Jennerian cow-pock. The vesicle (they said) was smaller than the original, and ran its course more quickly; and the want of the slight constitutional disturbance formerly observable at its maturity showed that the body of the subject was not thoroughly affected by the disorder. Hearing in 1838 of a renewed outbreak of cow-pox among cows at Berkeley, Mr. J. B. Estlin (whose pupil I had been) went down thither, and brought back a supply of original vaccine lymph, which (with the assistance of his brother practitioners) was soon diffused through Bristol and its neighborhood, and proved to reproduce the characteristic Jennerian vesicle. The circumstances attending this reintroduction of an original *vaccinia*, which I have recently detailed elsewhere,* strongly impressed me with the idea that the vaccine virus became "tempered" (so to speak) by passing through the human body, its original potency suffering diminution with the increase in the number of subjects through which it had been transmitted; while, at the same time, the proportion of subjects in whom the vaccination "took," which had been small with the original "vaccine," increased when it had (so to speak) become "humanized." This gradual modification we now understand to be the natural result of the continued "cultivation" of vaccinia in the human body; so that the diminution of the protective power of vaccination by such "cultivation" through a long succession of generations is just what might be scientifically expected. A most curious proof of the modification which *vaccinia*, thus humanized, has undergone, is afforded by the experiments of Dr. Martin (of Foxborough, Massachusetts), who states that, while there is no difficulty in keeping up an *original* vaccinia for any length of time by continuous transmission through heifers, the *humanized* vaccinia, if recommunicated to heifers, soon dies out, this retro-vaccination (as

* See the "Lancet," May 10th.

Dr. Martin terms it) *never succeeding beyond the third remove* from the human into the bovine subject.

There can now, therefore, be no reasonable doubt that a very large proportion of the failures, triumphantly adduced by anti-vaccinationists as proofs that the alleged protective power of vaccination is a mere assumption, are attributable to this degeneration, the protection diminishing with the "humanization" of the virus employed, and this being proportional to the remoteness of its derivation from the bovine stock.

During the war between the Northern and Southern States, Dr. Martin (who had previously acquired a reputation for special knowledge of this subject) was specially employed by the Government of the North to proceed to the various localities in which severe outbreaks of small-pox were from time to time taking place, and he most commonly found that there had either been no previous vaccination at all or vaccination with degenerate virus. Armed with a supply of good lymph, and with military authority (which enabled him to practice a really *compulsory* vaccination and revaccination), he always found himself able to control these outbreaks, and to prevent their recurrence. Anxious, however, to obtain (if possible) a fresh primary stock of vaccine, he advertised extensively for information as to any *original* case of cow-pock, but could hear of none. And he then imported from France some dried lymph of what is known as the "Bougival" stock, which had been continuously transmitted, through a long succession of heifers, from its original bovine parentage in that place. This transmission he has himself kept up in the neighborhood of Boston (New England) for the last ten years; and he assures me—1. That vaccination from this heifer-stock, if practiced according to his instructions, is quite as successful (in regard to the proportion of cases in which it "takes") as vaccination from the human arm; 2. That the vesicle produced by it is always of the true old Jennerian type, no deterioration having taken place in its long descent from the original stock, such as is produced by "humanization"; 3. That he has never seen either erysipelas or any other of the "accidents" which sometimes (as in my own Bristol experience in 1838) attend the direct vaccination from the *original* cow-stock; and, 4. That, having offered a considerable reward in all the principal towns of the Union for information as to the occurrence of any case of small-pox within ten years after thorough vaccination with his heifer-lymph, this reward has never been claimed; although, since its introduction, the United States have been traversed (in the years 1874–'76) by an epidemic of small-pox, which will be long remembered there for its peculiar virulence and the wide-spread mortality it occasioned.*

* The distinguished American physicians, whose attendance at the recent Congress gave me the opportunity of conversing with them on this subject, entirely confirmed Dr. Martin's account of the severity of that epidemic, which, in some respects, bore such a

This epidemic was clearly the same as that which had prevailed, with somewhat of the same severity, not only in this country, but also over the greater part of the Continent of Europe, two years previously; and hence there can be little doubt that the high rate of mortality by which it was everywhere characterized must have been due to general rather than to local causes. It had the good effect of frightening many of our local health authorities into a more efficient observance of their duty in regard to vaccination; and the result has been that, during the last two years, the reports of the Registrar-General show an *almost complete extinction* of small-pox in the nineteen great towns, whose aggregate population (about three and three quarter millions) equals that of the metropolis. The fresh outbreak which has taken place during the first half of the present year has been almost entirely restricted to the London area, and evidently points to the importance of a more strict enforcement of the vaccination law, which is at present rendered nugatory, as regards no inconsiderable proportion of the metropolitan population, by the migration of families from one district to another.

The prolonged experience of Dr. Martin, in regard to the facility of keeping up heifer-vaccination continuously from the original stock, altogether confirmatory as it is of what has been reported on this subject from France, Belgium, and St. Petersburg, seems to me to justify the demand that our Government should maintain the requisite establishment on a sufficient scale to meet the requirements of the whole country, so that every vaccination and revaccination may be performed (if desired) with lymph derived from the original cow-stock, without any humanization whatever.* The vaccinia of Jenner may be thus maintained in its original efficacy, without the impairment of its protective influence by prolonged "cultivation" in the human subject, and thus only can it be secured against the contaminating influence of human disease, the liability to which furnishes the anti-vaccinationists with their strongest weapon.

No benefit can be reasonably expected from the adoption of any system which is based on the induction of vaccinia in a calf or

resemblance to the "Black Death" that carried off what was estimated at *one third* of the population of Europe in the fourteenth century, as to suggest that the latter may have been really a peculiarly malignant small-pox. My friends greatly regretted the want in the United States of a system of "compulsory" vaccination; but said that, when outbreaks of small-pox occurred in their towns, the municipal authorities took the matter in hand, and insisted on the immediate vaccination and revaccination of all dwellers in the infected localities, by which means these outbreaks were brought under control. As there is no registration system in the American Union, I could not obtain any definite information as to the amount of its small-pox mortality; but no one seemed to entertain the least doubt as to the preventive efficacy of vaccination.

* I am assured by Dr. Martin that vaccination with heifer-lymph dried on ivory "points" succeeds in as large a proportion of cases as vaccination with fresh human lymph, provided that it be practiced according to the method which his large experience has led him to adopt as the most effective.

heifer, by inoculation with lymph which has been "humanized" by long transmission through a succession of human beings. For, as is proved by Dr. Martin's experiments on this *retro*-vaccination, such lymph has been so altered by "humanization" that the germs it contains do not properly reproduce themselves in the system of the calf, thus showing that it no longer possesses the attributes of true vaccinia. And, although the liability to contamination from human disease may be thus greatly diminished, it can not be certainly said to have been destroyed.

We now come to the bearing of Pasteur's researches on the question of the fundamental identity of small-pox and cow-pox, originally mooted by Jenner. Attempts at its solution were made, early in the present century, by the inoculation of bovine animals with small-pox virus; and it was asserted that in this way true vaccinia had been artificially produced. But the evidence in support of this assertion did not command general assent; and it was not until Dr. Thiele, of Kazan, published, about forty years ago, an account of his experiments, that the doctrine obtained any considerable amount of acceptance. According to the citations given by Mr. Simon, in his valuable "Report on Small-pox and Vaccination," issued under Government authority, in 1857, Dr. Thiele not only repeatedly succeeded in producing a genuine vaccinia by inoculating bovine animals with small-pox virus, but himself used this artificial vaccine largely and successfully in human vaccination, and propagated it extensively by the instrumentality of other vaccinators, its protective power being found to be fully equal to that of the natural vaccinia. But, further, Dr. Thiele asserted that he could produce this artificial vaccine without the use of the cow at all, by *diluting the small-pox virus with warm milk*, or, as we should now term it, "cultivating" its living germs in that fluid. I can scarcely help thinking that the great improbability—as it *then* seemed—of such a conversion has thrown a discredit upon the whole of Dr. Thiele's statements, which has caused them to be ignored by most subsequent workers on this subject. But, should that part of his results be ever confirmed, he must be accorded the credit of having anticipated in a most remarkable way one of the most important of Pasteur's methods, though, it is pretty certain, without knowing, or even guessing, their true *rationale*; for it must have been not by *dilution* of the virus (like that of a chemically acting fluid), but by a *modification in the character of the disease-germs* resulting from their development in milk, that this part of Thiele's results (supposing them to be genuine) was produced.

Simultaneously with those of Dr. Thiele, a set of experiments of the same kind was being carried on in our own country by Mr. Ceely, of Aylesbury; the results of which, however, were not equally satisfactory. He did, it is true, produce an eruption in cows inoculated with small-pox virus, which was transmissible by inoculation to the

human subject, but this eruption seems to have had rather the character of a modified *variola* than that of a true *vaccinia;* and, as its transmission by inoculation through a succession of human subjects did not produce what the best judges considered a genuine cow-pock, it was allowed to die out. The case was very different, however, with another set of experiments made a few years afterward (in ignorance of Mr. Ceely's) by Mr. Badcock, a druggist at Brighton, who was led to institute them through having himself suffered an attack of small-pox, though vaccinated in early life, and having been thus led to suspect that the protective power of vaccination had undergone deterioration. From the account he gave of his work in a small pamphlet published in 1845 (for a sight of which I am indebted to his son), it appears—1. That he inoculated his cows with small-pox virus furnished to him from an unquestionable source;* 2. That this inoculation produced vesicles which were pronounced by some of the best practitioners of Brighton to have the characters of genuine vaccinia; 3. That lymph drawn from these vesicles, and introduced by inoculation into the arms of children, produced in them vaccine vesicles of the true Jennerian type; 4. That free exposure of some of these children to small-pox infection showed them to have acquired a complete protection; and, 5. That this new stock of "vaccine" had been extensively diffused through the country, and had been fully approved by the best judges of true *vaccinia*, both in London and the provinces.

Mr. Simon, writing in 1857, stated that, from the new stock thus obtained by Mr. Badcock (not once only, but repeatedly), more than 14,000 persons had been vaccinated by Mr. Badcock himself, and that he had furnished supplies of his lymph to more than 4,000 medical practitioners. And I learn from Mr. Badcock, junior, who is now a public vaccinator at Brighton, that this stock is still in use in that town and neighborhood.

Against these *positive* results are to be set the *negative* results of attempts made in the same direction by many other able experimenters, such as Professor Chauveau and his coadjutors, the recent Belgian Commission, and Professor Burdon-Sanderson, as well as the unsatisfactory results obtained by Ceely. But I can not see that their *non*-successes are in any way contradictory of the *absolute* and *complete* successes which, if testimony is to be trusted, were obtained by Thiele and Badcock. The lesson taught by the failures appears to me to be the careful imitation of the conditions under which the successes were obtained; and, as Mr. Badcock, senior, is still living, and is said to be both able and willing to give all needful information, it is the inten-

* The only possible fallacy in these experiments, as it seems to me, might lie in his medical friend, Mr. (afterward Sir J.) Cordy Burrows, having supplied him with vaccine lymph, instead of with variolous virus. But, though this might have been the case once or twice, it could scarcely have happened several times, except by *design*, which is scarcely to be thought of.

tion of Professor Burdon-Sanderson and myself to take an early opportunity of personally obtaining this from him, with a view to a careful and thorough testing of his experiments, with every precaution that experience can devise.

The recent meeting of the Medical Congress has given me the opportunity of personal communication on this subject both with M. Pasteur and M. Chauveau. From the former I learned that his use of the term "vaccination" in connection with his employment of the mitigated virus of "charbon" and "chicken-cholera," as a protective against the malignant forms of those diseases, was intended rather as a compliment to Jenner than as expressive of any belief in the identity of vaccinia and variola. This question, he said, was one which he had not himself investigated, and on which he did not feel himself justified in forming an opinion. But, when I asked him whether he considered it to have been already decided in the negative, and further informed him of the positive evidence afforded by Mr. Badcock's experiments, he expressed himself strongly in favor of regarding the question as still *open*, to be decided by further researches carried on under the new light afforded by the results of his own recent investigations. I found M. Chauveau himself not less willing to admit the force of the strong analogy between the protective agency of the Jennerian and what I may term the Pastorian "vaccination," and not less ready to accept the results of any thorough reinvestigation of the subject. Such a reinvestigation I hope shortly to see carried out at the Brown Institution by the accomplished young successor to Professor Greenfield, under the superintendence and with the co-operation of Professor Burdon-Sanderson, in whose great knowledge, long experience, and wise judgment, all who know him and his pathological work have the fullest confidence.

Now, putting altogether on one side the purely scientific interest of this investigation, let us see in what position we shall be, if it should issue in the confirmation of Jenner's view of the fundamental identity of *vaccinia* and *variola*, proving cow-pox to be not a disease *sui generis*, but small-pox modified by passing through the cow.

In the first place, we shall have the *scientific basis* for the practice of vaccination, which it has never yet possessed; for it will be then clear that the protective power of vaccination is exactly the same in *kind*—as it has long been known to be about the same in *degree*—as that of a first attack of small-pox.

Secondly, the "common-sense" argument in favor of vaccination will be greatly strengthened by the proof that we are not poisoning the blood of our children with a new disease (which some of the most vehement of the anti-vaccinationists maintain to be already destroying the vitality of the nation), but are merely imparting to them in its mildest form a disease which every one is liable, without such protec-

tion, to take at any time. Those who would hasten to protect their flocks and herds by Pastorian "vaccination" against a deadly "charbon" raging in their neighborhood—as who would not?—can not, in common consistency, refuse Jennerian vaccination for their children.

And, thirdly, we shall be furnished with the means of obtaining, at any time, an original stock of *vaccinia*, the continuous transmission of which through a succession of heifers will at the same time secure the maintenance of its potency, and exclude the chance of human contamination.

Among the numerous other researches now being followed out on the Pastorian lines, I may notice two as likely to prove of the highest practical importance: those which, in the hands of Drs. Klebs and Tommasi Crudeli, seem likely to demonstrate that *marsh-malaria* derive their potency from organic germs (an idea that singularly harmonizes with the *periodicity* which is the special character of the varied forms of disease they induce), and those which, based on the original discovery of Villemin (in 1865) as to the communicability of *tubercle* by inoculation, are rendering it probable that this terrible scourge (including not only pulmonary consumption, but scrofulous disease in all its varied forms) really depends on the presence of a microphyte, which may be introduced into the body, not merely by direct passage into the blood-current (as in inoculation), but also through the alimentary canal, or even through the lungs. This doctrine, which was first advanced by Professor Klebs four years ago, has lately been the subject of most careful research by Dr. Schüller, of Greifswald, who has shown that every form of tuberculosis can thus be artificially induced, the characteristic micrococcus spreading rapidly in the blood and tissues of the animal inoculated with it; and that if, in an animal so infected, any joint is experimentally injured, that joint at once becomes a place of preferential resort to the micrococcus, and the special or exclusive seat of characteristic tubercular changes—a fact of the utmost practical interest in its relation to human joint-diseases. Another line of inquiry, which has obviously the most important bearing upon human welfare, is the propagability of the micrococcus of tubercle by the milk of cows affected with tuberculosis, a question in regard to which some very striking facts were brought before the Medical Congress by a promising young pathologist, Dr. Creighton.

Well might Mr. Simon conclude his admirable address as President of the Public Health Section of the Congress with these pregnant words: "I venture to say that in the records of human industry it would be impossible to point to work of more promise to the world than these various contributions to the knowledge of disease, and of its cure and prevention; and they are contributions which, from the nature of the case, have come, and could only have come, from the performance of experiments on living animals."—*Nineteenth Century.*

M. PAUL BROCA.

M. BROCA, says his friend Jacques Bertillon, worked all his life, and at tasks of very different sorts. "Rarely has there been a mind so active, so equally open to all kinds of knowledge, and so equally fond of all kinds. M. Elisée Reclus, who was his associate in college, tells that he said to him very early in life: 'I do not believe in vocations; a man may select a career almost at random, he will always make a place for himself in it according to his cut.' M. Broca judged others according to himself, and in that went too far, but, as concerned himself, he judged aright." M. Verneuil, pronouncing a funeral eulogy upon him before the Faculty of Medicine, remarked that his life might be shown up as a model to those who desired to become in that profession first pupils, then assistants, and at last masters. In whatever station he was placed, the eulogist added, M. Broca always fulfilled his commission with exemplary exactness and zeal, and, rather than think of avoiding the most trifling item in his programme, he was inclined to charge himself unnecessarily in the fear that he might not be carrying a load proportioned to his strength.

PAUL BROCA was born at Sainte-Foy-la-Grande, in the Gironde, June 28, 1824. The Brocas were of an old Huguenot family, which had included several of the famous brave "pastors of the desert," who suffered in the times of persecution. Broca's father had served in the Spanish wars, and had contracted a profound hatred of the spirit of despotism in which they originated, and were waged; and young Broca was vividly impressed with the reality of the principles of civil and religious liberty, at six years of age, when the Catholics of Sainte-Foy rose against the Government of July, 1830. In 1832 he entered the Communal College of Sainte-Foy, an institution which was then frequented by all the Protestant youth of France, and at which most of the distinguished men of the Reformed Churches were educated. Broca's father wished him to study medicine. He, having a taste for mathematics, preferred the Polytechnic School. He secretly prepared a baccalaureate in science, and having taken the degree of Bachelor in Letters, first in rank, in 1840, when only sixteen years old, he gained permission from his father to be examined for the bachelor's degree in mathematical sciences. Having gained this, he began to prepare himself for the Polytechnic, teaching in the day-time in the college where he had been a student, studying the calculus at night. His plans were suddenly changed by the death of his sister. He was now an only child, and would not embrace a profession that would call him away from his parents. He resolved to study medicine, and share his father's practice at Sainte-Foy.

He was enrolled in the Faculty of Medicine at Paris in November,

1841, and passed successfully through the several competitive examinations, till he became Anatomy Assistant of the Faculty in 1846, Prosector of the Faculty in 1848, and Doctor of Medicine in 1849; and while waiting the aggregate competition, which would not take place for several years, he gave lectures on surgery and operative medicine at the Practical School. Numerous works already gave promise of what the future had in store for him. The bulletins of the Anatomical Society contain several papers which are still in repute on various difficult subjects of pathology. "There is hardly one of these subjects," says his biographer, Dr. Pozzi, "in which he did not at the first stroke make a discovery great or small; there is not one, at any rate, in which he has not left the mark of his originality." At the aggregate competition, which he had been awaiting, Broca displayed an amount of knowledge and an erudition with which the judges were strongly impressed. His thesis was a finished work on one of the most difficult subjects in surgery. He was named first in promotion. At the same time he received, at the competition of the Central Bureau, the title of Surgeon of the Hospitals. He formed many and solid friendships, and exercised, through the superiority of his mind and his integrity, a real intellectual and moral authority.

Till 1859, Broca's labors were exclusively anatomical and surgical. His treatises on "Aneurisms and their Treatment" and on "Tumors" have become celebrated. About two hundred studies on the most various subjects, among which may be mentioned especially his researches on articular cartilages and their pathology, belong to this period.

In the preface to his work on aneurisms, Broca makes an exposition of the principles by which he was guided, which Dr. Pozzi regards as worthy of being made the confession of faith of a scientific writer. "I have desired," he says, "to submit received doctrines and opinions to an independent criticism, knowing well that real science is still hardly in its dawn, and that the most undisputed assertions are frequently the most assailable; I have aimed to set classic descriptions in the face of positive observations, appealing to the experience of surgeons of all countries, profiting by ancient and modern facts, checking one with another, despising none, and seeking before everything the reality, although authority may suffer for it. And I have made it my duty to go back to the origin of our knowledge, to follow ideas and discoveries from their birth to their complete development, and to consecrate the rights often slighted of the true inventors. This alliance of criticism and observation, of clinics and history, is destined gradually to regenerate surgery by delivering it at the same time from tradition and empiricism, from the spirit of routine and the spirit of system, from the sterile erudition of those who look only at the past, and the convenient ignorance of those who are occupied only with the present."

Broca had a high opinion of the value of statistics, and employed them extensively in his researches, as constituting a sure basis for sound conclusions. He uttered a very expressive appreciation of them when he said once in the Academy of Medicine: "Statistics are the anatomy and physiology of the social body. Without them, we grasp only little groups, our judgments are mere impressions, and, even if these impressions do not deceive us, they make us but imperfectly acquainted with facts that are only partial, and the laws of which escape us." Applying the method of means derived from statistics to anatomy, he renovated and almost created anthropology.

After 1859, Broca pursued a double purpose. Without neglecting any of his manifold medical duties, he undertook the considerable task of founding a new society, and almost of a new science. The incidents which led to this step date from 1847, when Broca, as medical assistant, was appointed for the study of the bones, upon a special commission charged with making a report on the excavations in the Church of the Celestins. In preparing to draw up his report, he was led to read the works in which craniology was discussed; and thenceforth, although his competitions drew him to different studies, he continued to read with a lively interest the books, then rare, which treated of man and the human races. The ethnology of the day tended to contract its programme around the then overshadowing question of monogeny or polygeny, and the Ethnological Society of Paris had so exhausted itself with the reiteration of its narrow debates that it had ceased to meet in 1848. Ten years afterward, Broca, having brought out certain facts in hybridity, desired to communicate them to the Society of Biology. He had not foreseen the pusillanimity of some of his colleagues. Some of his positions were contradictory of the doctrine of the monogenists, and Rayer, president of the society, alarmed at the views contained in it, asked Broca to withhold his communications on the subject. He accordingly sought another channel for the publication of his memoir.

This incident, which greatly disturbed the Biological Society, suggested the necessity of founding a new society, in which questions relating to mankind could be given free scope. The project had to make its way against difficulties. Broca wanted to obtain twenty members, but, after a whole year of effort, he had to begin with nineteen. Then there was trouble in getting an authorization for the meeting of the society. The Government officers were afraid of its name, apprehending that the strange word "anthropology" might cover some political or social scheme. Finally, the prefect of the police, judging that a meeting of one short of twenty persons did not require special authorization, gave Broca permission to meet with his friends, on condition that he should be personally responsible for all that might be said against society, religion, or the Government, and that an agent of police should always be present in citizen's dress to

see that no harm was done. Broca, says M. E. W. Brabrock, of the Anthropological Institute, "liked to tell an amusing anecdote on the subject of this supervision: The police officer acquitted himself of his mission with so great regularity, and had got so much the habit of sitting among the members, that he seemed soon to have forgotten that he was there in a special capacity. Wishing one day to be able to take a holiday with a clear conscience, he approached the officers with an amiable smile, and addressed Broca: 'There will be nothing interesting to-day, I suppose? May I go?' 'No, no, my friend,' Broca immediately replied, 'you must not go for a walk; sit down and earn your pay.' He returned to his place very unwillingly, and never after ventured to ask a holiday from those he was set to look after."

The society held its first meeting May 19, 1859. When it was seen at work, adhesions came fast; and after it had published the first volume of its "Bulletins," and shown the exclusively scientific character of its labors, the suspicions which it had excited before its birth began to subside. The Minister of Public Instruction deigned at last to authorize it in 1861, and three years afterward it was recognized as a society of public utility. M. Broca, all agree, was the soul of this society. Having founded it, he kept it alive during its perilous early years by the prepondering interest of his incessant labors, and the communicative ardor of his devotion to the young science. He had the faculty of grouping the most diverse, and, apparently, the most discordant, elements around his person; the power to excite the zeal of some, restrain the passion of others, and to exercise over all an authority that was incontestable and uncontested, simply because it rested solely upon his real superiority freely recognized by all. This influence of Broca, visible particularly at the beginning, continued no less real till the last days of his life, notwithstanding he took pains to avoid everything that might give him the appearance of a personal direction. He was secretary of the society for the first three years, and was accustomed to record its debates from memory after the meetings were over, in a manner that heightened their original interest and gave prominence to the central point of the debate. In 1863 the growth of the society had made the office of a general secretary necessary. Broca was elected to the position, and held it till his death.

In 1861 Broca began his admirable researches on the brain. In a series of four memoirs he gave reasons for the belief that the brain was not, as many at the time thought, "an undivided organ in which the different faculties have no determined seat," but that the fundamental convolutions of the cerebral hemispheres are distinct organs, each having distinct functions. Performing an autopsy upon a man who had been deprived of the faculty of speech for twenty years, he was led, by a careful examination of the condition of his brain, to the conviction that the primary seat of his affection was in the third con-

volution of the left frontal lobe. Other facts came in to confirm his view, and this part of the organ, now generally known as the "convolution of Broca," has been determined to be the center of the faculty of speech.

In the two manuals which Broca published as guides to the studies of general anthropology and craniology, he condensed in a few pages the work of several years. He insisted especially on the importance of accurate measurements, and of having conclusions supported by the averages of a large number of experimental cases. For these purposes he invented more than thirty simple, accurate, and convenient instruments of measurement. His anthropological memoirs are numerous, and pertain to all branches of the science, prehistorical, historical, ethnographical, and linguistic, and repeatedly illustrate the activity and encyclopedic comprehension of his intellect. He had begun to collect them in a series of volumes, of which three have been published and a fourth is in preparation. During the later years of his life he was chiefly interested in cerebral morphology; and he was engaged, when he was surprised by death, in a complete work on the morphology of the brain, to constitute a masterly summary of the result of his studies. Though it is unfinished, this valuable manuscript will not be lost to science. Its scattered leaves have been collected, and will be eventually published.

Broca intermitted his anthropological labors during the Franco-German War, in order to serve his country as one of the three directors of Public Assistance. Here it was his privilege, by the exercise of considerable prudence and tact, to save the funds of the department, amounting to 75,000,000 francs (or $15,000,000), from plunder by the Communists. While others were ready to boast of their services, and claim recognition for them after order was restored, Broca made no allusion to what he had done. He resumed his studies during the second siege, occupying himself in the formation of the collection of cerebral models in the laboratory. He founded the "Revue d'Anthropologie" in January, 1872, and in the same year took part in the formation of the French Association for the Advancement of the Sciences, in which he became the leading spirit in the Anthropological Section.

The foundation of the Anthropological School, and its installation in rooms dependent on the Faculty of Medicine, was due to Broca's personal influence and zeal. The period of preparation for the opening of the institution was fraught with perils to it arising from the opposition of the clerical party and the timidity of the Government. The school, the laboratory, and the Anthropological Society, meeting in the same place, are now together known as the Anthropological Institute.

At the beginning of 1880 M. Broca was elected Senator for life. Shortly afterward he wrote in reply to the congratulations of an English club over his new advancement: "In choosing their candidate for

the first time from outside the political world, the 'Left' of the Senate have wished to manifest their good disposition toward the sciences; and, if I am happy in having been chosen on that ground, I am especially happy that anthropology should have acquired so much importance in public opinion as to be called to have its representative in the Senate." A banquet was given him by his friends in honor of his nomination, when he made a remark which had a singular bearing in connection with his sudden death: "My friends, I am too happy. . . . Yes, I am too happy. If I was superstitious, I should regard my nomination to the Senate as the presage of some great misfortune, perhaps as the presage of death." On the 6th of July, 1880, he was seized with a fainting-fit at his place in the Senate. He resumed his work on the two following days, but was attacked again at midnight on the 8th, and died in ten minutes. His organs were found to be all sound, and his death was attributed to cerebral exhaustion arising from overwork.

For forty years Broca lived a life of persistent work. While still a student, he would pass his nights reading scientific works and journals pen in hand, to note down what he found most interesting. For three years, although he was otherwise the busiest of the professors, he delivered his lectures twice a week, while his colleagues were satisfied to give a single lesson. He was accustomed to spend much time every day at the laboratory, dissecting, drawing, or superintending the modeling and classification of new specimens; and he also devoted most of his evenings to anthropology. The pressure of his duties finally became so great that he could only afford one hour an evening for his favorite work, and he took from eleven o'clock till midnight, promising his family that he would not study later.

As a teacher, says M. Bertillon, he was clearness itself. His passion for truth spoke in his lectures, and he would never leave a subject till he could see the understanding of it reflected in the face of every hearer down to the simplest child. He was always ready to ignore the interests of his own ambition for the sake of those of science, and insisted on retiring from the presidency of the Anthropological Section of the French Association in 1876, so that the honor might be open to others. His style was simple and elegant, and combined the graces of the man of taste and the lover of poetry with the preciseness of the scientific student. In his personality his features were less important than the expression that animated them. In personal intercourse his vivacity, his originality, his fertile memory, and his inexhaustible resources in quotations and anecdotes, made him a charming talker. He was as familiar with questions of æsthetics and literature as with those of politics and science; was interested in everything, and had his own well-reasoned views on everything. In all things love of truth was the great passion of his life.

CORRESPONDENCE.

WHERE DO THE MEMBERS OF THE AMERICAN SCIENTIFIC ASSOCIATION COME FROM?

Messrs. Editors.

HAVING had a curiosity to know, in something more than a general way, how the various sections of the country contribute to the attendance at the meetings of the American Association for the Advancement of Science, I have analyzed the "registers of arrivals" of the Boston and Cincinati meetings. The results, which may be of interest to others as well, are embodied in the following tables. In checking off so many names, there is, of course, liability to error, but some pains have been taken to make the statement correct. E.

TABLE I.—ATTENDANCE BY STATES.

STATES.	Boston meeting, 1880.	Cincinnati meeting, 1881.
Maine	14	2
New Hampshire	17	0
Vermont	7	0
Massachusetts	221*	23
Rhode Island	17	1
Connecticut	39—315	11—37
New York	170	45
New Jersey	36	3
Pennsylvania	47	18
Delaware	1—254	0—66
Wisconsin	4	8
Michigan	7	10
Indiana	8	29
Illinois	21	27
Ohio	22	61†
Kentucky	9	25
West Virginia	1	3
Virginia	3	2
Maryland	16	18
District of Columbia	71—162	30—208
Tennessee	6	8
North Carolina	2	2
Georgia	2	4
Florida	1	3
Alabama	1	2
Mississippi	0—12	3—22
Louisiana	1	2
Missouri	32	18
Iowa	9	8
Minnesota	4	3
Kansas	2	1
Colorado	0	3
Arizona	3	0
Nebraska	0	1
California	1—52	8—39
British Provinces	21	4
England	5	0
Cuba	3	0
Boston‡	164	0
Cincinnati‡	0	155
	988	531

* Excluding Boston.
† Excluding Cincinnati.
‡ The two or three names without addresses have been credited to the entertaining city.

TABLE II.—ATTENDANCE BY SECTIONS.

SECTIONS.	BOSTON MEETING.		CINCINNATI MEETING.	
	No.	Per ct.	No.	Per ct.
From New England	315	31·9	37	7·0
From the Middle States	254	25·7	66	12·4
From the Western States east of the Mississippi, and as far south as Kentucky and Virginia	162	16·4	208	39·2
From the Southern States east of the Mississippi	12	1·2	22	4·2
From west of the Mississippi	52	5·3	39	7·3
From the British Provinces and beyond the sea	29	2·9	4	0·7
From the entertaining city	164	16·6	155	29·2
Totals	988	100·0	531	100·0

IDENTITY OF THE INDIANS AND THE MOUND-BUILDERS.

Messrs. Editors.

IN 1875 I read a paper before the Iowa Academy of Science, on "The Mounds and Mound-Builders," in which I took the same grounds and came to the same conclusion as Professor Winchell, in his recent article on the "Ancient Copper-Mines of Isle Royale." My article was suggested by the examination of some mounds on the bank of the Mississippi, in Whitesides County, Illinois.

Among other things exhumed were one or two skeletons with anchyloses of the first and second vertebræ, and quite a number with *flattened shin-bones*, and also a flattened or deformed skull. In 1864–'65 there was a large number of Sioux Indians, concerned in the massacre at New Ulm, Minnesota, in the prison-camp at Davenport, Iowa. Dr. R. J. Farquharson, of that place, two or three years ago disinterred several skeletons of the prisoners who died there. He found one with the first and second vertebræ anchylosed, and several with flattened tibia, showing that *platycnemism* still exists among the modern tribes, and connects them with the mound-builders.

Very respectfully,
P. J. FARNSWORTH.

CLINTON, IOWA, *September* 1, 1881.

A CORRECTION.

Messrs. Editors.

IN your sketch of Edward D. Cope in the May number of "The Popular Science Monthly," the following statement occurs

on page 111: "His Western explorations were begun in 1870, when he visited the cretaceous region of Western Kansas." Is not this date a mistake? Professor Marsh, of Yale College, in November, 1870, fitted out an expedition at Fort Wallace, and explored the cretaceous deposits of Western Kansas during November and December of that year. In June, 1871, he again started with an expedition from the same fort, and spent about two months in exploring the same region.

I am quite sure that Professor Cope did not visit Western Kansas until after Professor Marsh's second season's work was completed.

There are some other similar errors in this sketch which should perhaps be noticed, but the one mentioned I can correct of my own knowledge. M. D.

MANHATTAN, KANSAS, *October* 25, 1881.

INFLUENCE OF TEMPERATURE ON THE CHIRP OF THE CRICKET.

Messrs. Editors.

SOME years ago my attention was called to the crickets which chirp so incessantly every summer evening, and it was thought by a friend that they varied in the number of their chirps per minute — at a higher temperature vibrating much faster. At that time a single observation was made, but for some reason was not repeated.

Recently, a writer in the "Salem Gazette," signing himself W. G. B., gives the following rule for estimating the temperature of the air by the number of chirps made by the crickets per minute: "Take seventy-two as the number of strokes per minute at 60° temperature, and for every four strokes more add 1°, and for every four strokes less deduct the same." After seeing this I determined to make a number of observations, to find out if this were an invariable rule. I tried it, with one or two exceptions, every night that the crickets chirped, from September 30th to October 17th. During this period a heavy frost occurred, when the crickets were not heard, but as soon as the weather grew warmer they began again. The lowest temperature at which they were heard was 50°. By the observations given, it will be seen that the temperature as estimated from the number of the crickets' chirps varies a degree or more from that recorded by the thermometer, but it must be remembered that no standard thermometer was used, and that the crickets were chirping in the trees, in many cases sheltered from the wind, while the thermometer hung near a window in a more exposed position; also, that on cool evenings it was very difficult to count the strokes, as they were feeble and interrupted. Below are given the observations for twelve evenings:

Date of observation.	Rate of vibration.	Temperature as computed by the rate of vibration.	Temperature as recorded by the thermometer.
Sept. 30.....	122	73°	70°
Oct. 3.....	115	71	70
" 7.....	67	59	59
" 8.....	104	68	67
" 9.....	74	61	59
" 9.....	64	58	57
" 10.....	42	52	50
" 12.....	66	58	56
" 13.....	118	72	70
" 16.....	81	63	63
" 16.....	73	60	60
" 17.....	57	56	54

It will be seen, by the above, that there is a remarkable accordance between the number of vibrations and the temperature of the air. With more accurate observations doubtless a closer agreement would be proved. MARGARETTE W. BROOKS.

SALEM, MASSACHUSETTS, *October* 22, 1881.

EDITOR'S TABLE.

FURTHER LESSONS OF THE YORKTOWN CENTENNIAL.

THE recent centennial proceedings at Yorktown, and the event they commemorated, have been so fully discussed in all quarters and in all aspects, that the topic is now pretty well exhausted. We certainly can not add anything to it in the way of novelty, but among the lessons that have been drawn from it there are some which deserve greater emphasis than they seem to have received. The orators of this occasion have expatiated much on the Yorktown surrender as a great step in the progress of human liberty: it is worth while to inquire to what extent and in what sense this is true.

The capture of Cornwallis ended a protracted war, and by the success of the insurgents turned the infamy of a rebellion into the glory of a revolution. It secured political independence, and

gave origin to a new nation. Yet the revolt was against the freest constitutional government in the world, and the communities that rose against the mother-country had been nurtured in the spirit of independence under British influence and British institutions. The justifying principle of the war was simply that the people on the spot, knowing their own circumstances and wants, could govern themselves better than they could be governed through agents by a people three thousand miles away. In reconstituting the government, various things deemed useless or injurious—hereditary monarchy, hereditary aristocracy, and a state Church—were lopped away as excrescences. But the constitution of the English law-making body was imitated, and the old common law of England, with its recognitions and guarantees of personal rights, and its machinery of justice, to which the people were accustomed, remained in substantial force. The bulwarks of civil liberty were a heritage from the parent country. In the declaration of political independence there was an affirmation of the natural and equal rights of all men. But it was little more than a "rhetorical flourish," as its reduction to living practice was scarcely thought of. There was a servile class stripped of all rights who sorely needed the benefit of this pretentious declaration, but it did not get it. In fact, the insurgent colonies were nothing less than slave-holding and slave-trading communities, and, when they deliberately proceeded to form a Constitution, human slavery was fortified in its provisions, and the foreign slave-trade was guaranteed for twenty years.

But if the Constitution of the new government left a weak and defenseless class a prey to its oppressors, was nothing gained for the superior race? Much, undoubtedly. There was a relief from monarchical, aristocratic, and hierarchical burdens, a simplification of political machinery, and an experiment in the direction of popular self-government. There was a transference of power into the hands of the people more complete than ever before. It was the boldest venture in representative government that had ever been made; yet, if we are to trust the official Yorktown orator, after the retrospect of a century, the problem is not yet solved, and we can not look forward to the next hundred years without profound solicitude.

But there was one grand stroke for the promotion of human liberty made in organizing the republic, the far-reaching consequences of which were neither appreciated by those who made it nor are they yet well comprehended by our people. We here refer to the liberty of commercial transactions, to the establishment of absolute free trade between the citizens of all the States of our political Union. An immense step was here taken in the progress of liberty. All the liberties—liberty of conscience, liberty of thought and speech, and liberty of exchange—have been slow growths; but no one has grown so slowly or against such resistance, or is still so immature, as that full liberty of action that is involved in the free exchange of property. It is here, in oppressive exactions upon exchange, that the most grinding tyranny takes effect; upon this point rapacious government is the first to fasten and the last to let go. Men may think and say what they like, and go where they like, but, if they can not dispose, unhindered, of the property which they have produced, and which is their own, their liberty is a delusion. Great progress has unquestionably been made in modern times in freeing exchange from its burdens, and all that had been gained was secured by the organic law of the new republic. It was decreed that Americans within the national limits shall be let alone—shall enjoy immunity from vexatious trade

restrictions—that is, shall be left free in all their industrial and commercial pursuits. Whatever may be the strength of local interests, whatever the advantages or drawbacks of States, they are for ever forbidden to interfere with the mutual liberties of exchange between citizens by tariffs, imposts, or any form of trade restrictions. No pretext of developing resources, diversifying industry, fostering weak interests, or protecting labor, could be made an excuse for commercial restrictions. It was ordained that business shall be left to voluntary enterprise, to the spontaneous impulses of private effort, and to stand upon the stable basis of its natural laws rather than upon the artificial support of regulative State legislation.

The good effects of this policy no man can now be found to question. A hundred years of experience has attested the practical wisdom and established the solid and permanent beneficence of this great constitutional measure. With trade as free as the winds, the result has been an unparalleled activity in the development of all resources, and a general prosperity such as the world has never before seen; while the open liberty of interchange, resulting in active and intimate intercourse, has favored political unity and strengthened amicable feeling between distant and diverse communities.

One has but to picture what the consequences would have been of applying protective theories to Northern and Southern, Eastern and Western States, to understand how vast has been the advantage of the free-trade policy. With the general ignorance that prevailed in regard to economical principles, the restrictive policy, if permitted at all, would have been driven to its last results. To have let State politicians loose upon our internal commerce would not only have abolished it, but would have aggravated local prejudice, narrowness of feeling, rivalries and jealousies, and engendered alienations and irritations that would have made national unity impossible. The fathers built wiser than they knew, and did the noblest service to human freedom which it was in their power to render when they united the American States on the basis of free trade.

This great lesson has not been lost, though it has not yet borne its full and final fruits. The policy which has proved of such immense benefit at home has not been trusted beyond the national borders. We adopt a partial practice with immense benefit, and then repudiate the principles it involves. Internal trade is free, but external trade is still shackled. A New-Yorker trades with a Pennsylvanian without restriction under the principle that they are the best judges of their own business affairs. They are free to buy and to sell as they like, and for the sufficient reason that the thing they will do is the best for both. But if a New-Yorker undertakes to trade with a Canadian, Government declares that the transaction shall not be free, the parties shall not do as they like with their own, and this for no other reason under heaven than because the Canadian is a foreigner. If Canada were "annexed," presto! these traders would at once know their own business best, and could exchange with perfect freedom.

We have here, in this surviving prejudice about the "foreigner," an illustration of the vicious potency of militant conceptions. The foreigner is our virtual enemy, one whom it is our patriotic duty to hate and not to help. The term is redolent of international antagonism and the pursuit of war which is the curse of civilization. This spirit, identified with the love of country, and fortified in long tradition, is slow to yield to the influence of humanizing and pacific agencies; but yield it must, and it has already greatly yielded, as witness the doings at Yorktown. That demonstration commemorated a military exploit; but ev-

erybody has seen that it was awkward, anomalous, and embarrassing. There was a great flaunting of military parade, suggestive of fighting; but, apart from the historic reminiscences, the speeches contradicted the whole spirit of the occasion. It was by no means devoted to unalloyed rejoicing over a military triumph, but was much more a tribute to the interests of peace and international friendliness. A hundred years makes a great difference nowadays, and the Yorktown utterances were significant registers of the progress of ideas. The new President spoke with wise discretion, and gave voice to the wishes of the American people by ordering that the commemorative services close with a salute to the British flag by the assembled forces of the army and navy, "in recognition of the friendly relations so long and so happily subsisting between Great Britain and the United States, in the trust and confidence of peace and good-will between the two countries for all the centuries to come, and especially as a mark of the profound respect entertained by the American people for the illustrious sovereign and gracious lady who sits upon the British throne."

Nothing could be more significant, as showing the growth of liberal ideas with reference to our external relations. It signalized the hope that time will secure in the family of nations what we have secured in the family of States. We can not expect peace "for all the centuries to come" except by cherishing the ideas and strengthening the sentiments and confirming the practices upon which peace depends. We can not have exemption from war if we cultivate the spirit of international antagonism—antagonism that tends to war. Nations must be knit together by closer links of mutual interest if peace is to be permanent. War isolates, destroys commercial intercourse, and drives nations into the policy of producing everything for themselves; and the feeling thus engendered by military domination in time of peace maintains barriers and repulsions between nations, on the plea that "we must not be dependent upon foreigners." The curses of war thus become perpetual. Its baneful influence lives on in the so-called "protective" policy which strangles foreign commerce, and compels a nation to shape all its internal affairs with a view, not to the interests of industry which demand the widest liberty of commercial expansion, but to the future contingencies of war.

MILITANCY AND INDUSTRIALISM IN VIRGINIA.

No better illustration can be desired of these views than that offered by the State of Virginia. Her citizens were certainly to be pardoned for their enthusiasm over the Yorktown pageant. The Revolution was consummated upon her soil, and she has a natural pride in all its reminiscences. But what a monument is that great State to-day of the scourge of war-ideas! Settled early as a colony, favorably situated in regard to climate, and with varied and boundless resources, she is nevertheless poor, incompetent, and backward in all the elements of public prosperity. If it be said that these calamities are due to slavery, we reply that slavery is only chronic and subdivided war. Slavery and war are kindred agencies, grown up together in a common barbarism, and both are despotisms of violence. Their one idea is the brute-force control of men—in war for the destruction of life and property, and in slavery for better ends. It was the cherishing of ideas common to slavery and war that drew Virginia with such facility into the vortex of domestic war. It was declining militancy rebelling against growing industrialism. How intense was the barbaric spirit is seen in the persistence of obsolete war-usages. Where militant ideas are ascendant, as in Germany and

France, dueling is habitual. And so, at the very height of the Yorktown celebration, one of Virginia's "captains," who had got a national reputation as a candidate for an office in the United States Senate, was principal in two duels in a single day; and when he returned to Richmond the same evening, instead of being "publicly flogged by a nigger," as he ought to have been, he received an "enthusiastic reception." Will the honor of its "chivalry" save the State from the disgrace of repudiation?

Militant ideas being opposed to business ideas, Virginia presents a case of arrested development. The world's beneficent work is mainly done by private enterprise; Virginia ideas have not favored this, and so she has been left behind in the race of State development. Legislation has been invoked to bring out her splendid resources, but there has still been wanting that vigor of private effort which can alone give effect to legislative measures. This is well shown in the history of one of her great public works. The project of opening commercial communication with the West was early entertained by sagacious Virginians. The distance of the Atlantic from the Ohio River through the valleys of the James and the Kanawha, which almost connect at their head-waters in the Alleghanies, is shorter than by any other route. It was a favorite idea of Washington to open this communication, and he strongly advocated a bill, passed by the Virginia Legislature in 1784, for the improvement of the James River, with a view to developing a Western water-communication. This project was worked at in an ineffectual way for a number of years, and in 1832 the James River and Kanawha Company was chartered to construct a canal up the James Valley, and this was opened between Richmond and Lynchburg in 1840. It was further extended to Buchanan, a distance of one hundred and ninety-seven miles from Richmond, in 1851. Some further work was begun beyond this point, to secure an avenue for through Western trade, but the sections beyond were not completed. The work as far as constructed was inadequate, only very small canal-boats being available; and so, in 1873, Congress was urged to assume, enlarge, and extend the work, which, in this era of developing railroads, it wisely declined to do. And then, after a hundred years of State efforts and the expenditure of ten million dollars, the undertaking completely broke down, and the dilapidated and useless canal property was offered to anybody gratuitously who would take it and pay its debts.

A couple of years ago a private company of Northern capitalists came forward and took the concern off the hands of the State, and proposed to see what could be done toward carrying out the original plan. They organized the Richmond and Alleghany Railroad Company, and, under the stimulus of intelligent business enterprise, and without a dollar of State aid, two hundred and fifty miles of solid road-bed, laid on the old tow-path as far as it went, with heavy steel rails and numerous iron bridges, were constructed through the valley of the James River to its head-waters in the Alleghanies *in eighteen months*. Seventy miles more will soon be built, connecting the new line with the Ohio Central, which terminates at Toledo—and the aspiration of Washington will be fulfilled.

While the military doings at Yorktown were at their height, absorbing the attention of Virginians, the formal opening of this railroad, replete with all modern improvements and appointments, took place. It was not so striking as the war-show, but it was of far greater moment to the prosperity of the Commonwealth. It was a *foreign* enterprise, made possible by free commerce, and inspired solely by the mercenary purpose of making money out of poor old Virginia; yet it was an ele-

ment of new life to that community, and will be to it even a greater source of wealth and advantage than to the speculators who carried out the work. Sordid commerce creates manufactures, advances agriculture, and, by increasing the occupations and remunerations of industry, increases all the benefits of civilization. Locomotives are missionaries without moral intentions. There was no patriotism, no philanthropy, no public spirit at the bottom of this movement, yet it will promote all these ends. Millions of Northern capital were poured out solely that they might be augmented, but in doing this they will develop a vast productive region, and aid in giving Virginia a new start in a new direction; and not the least advantage will be to compel the adoption of a new order of ideas.

OUR POLICY RESPECTING THE PANAMA CANAL.

THE letter of Secretary Blaine to Minister Lowell, of London, as to the policy of the United States in regard to the neutrality of the Panama Canal, deserves attention. Being a diplomatic document, it may not be easy to say what or how much meaning there is in it; but, as read by common-sense, it is a missive of intimidation, and contains a virtual threat of war. Mr. Blaine is, at any rate, playing with fire, and it is therefore well to watch him.

The canal, which opens a ship communication between the Atlantic and Pacific Oceans, being of vital moment to the commerce of the world, it is of the first importance to all nations that its neutrality be preserved inviolate; but as, in the rivalries and hostilities of nations, there would be danger that this neutrality might be violated, there arises the need of some strong arrangement to secure it. The United States of Colombia, across whose territory the canal passes, and which is therefore the rightful controller of it, is a weak power, and unable to protect the property from foreign interference. She consequently meets the necessity of the case and the requirements of nations by entering into treaty stipulations for guaranteeing the neutrality of the canal, or securing its equal benefits for all countries and at all times.

Now, Mr. Blaine informs whomsoever it may concern that this country has already attended to all this. He says, "The United States recognizes a proper guarantee of neutrality as essential to the construction and successful operation of any highway across the Isthmus of Panama," and that in 1846 it entered into a treaty with Colombia for that purpose.

But that treaty was made under no immediate expectation of the construction of a canal: it was shaped in the light of history by which this country was on record as friendly to the project. Yet, when the undertaking begins first to take practical shape, and the desideratum of centuries promises to be realized, it turns out that the United States is no longer anxious about it. In fact, there was recently developed throughout the country an unmistakable hostility to it. We would neither build it ourselves nor help others to build it, and did all we could to discourage the work by trying to alarm foreign capitalists and prevent them from furnishing the funds for its construction. In this state of things—this sudden abandonment of a clearly defined historic policy—Colombia very naturally began to query as to the satisfactoriness of the guarantee of a power that had ceased to care about the legitimate objects of the work, and had, in fact, developed a feeling inimical to it. They, therefore, began to raise the question of securing the neutrality of the canal by treaty with European powers; and these, it is apprehended, entertain the idea of re-enforcing the American guarantee. Mr. Blaine says, in behalf of this Government, that such a course is inadmissible; and he instructs Mr. Low-

ell to inform Lord Granville, on the part of the English Government, "that any movement in the sense of supplementing the guarantee contained therein" (that is, in the treaty with Colombia) "would necessarily be regarded by this government as an uncalled-for intrusion into a field where the local and general interests of the United States of America must be considered before any other power, save those of the United States of Colombia alone"; any such movement "would be an extraordinary procedure, and would necessarily be viewed by this Government with the gravest concern"; and, moreover, "would partake of the nature of an alliance against the United States, and would be regarded by this Government as an indication of unfriendly feeling."

Now, if a guarantee in this case is the right thing, and if a valid guarantee of neutrality is really wanted, common-sense fails to see how it can be so well secured as by treaty compact on the part of all the powers from whom there may ever be danger of its violation. If desired at all, the stronger it can be made the better; and, if this strengthening is objected to, what else can it mean than that the objector has a sinister object, and does not want a *bona fide* guarantee? The plain import of Mr. Blaine's letter is this: There shall be no comprehensive and efficacious international guarantee of the neutrality of the interoceanic canal; the United States will give such a guarantee as it thinks "proper"; it will take exclusive possession of the canal, regardless of the nation within whose territory it is, and it will itself violate its neutrality whenever its own interests may dictate such a course.

And what are those interests? They are not the bonds of commerce. The nation has gone far to put itself outside the pale of civilization by the destruction of its outside commercial relations. It has "protected" what commerce it had to death, and insanely persists in the policy by which it can never be restored to life. As a consequence, it had no need of a Panama Canal, and has no concern about it now, except to get exclusive possession of it for use in the contingency of war.

The New York "Evening Post" undoubtedly gives us the point of Mr. Blaine's letter when it remarks, "We can not say too plainly that we mean to protect the canal ourselves exclusively." But what, then, can be Mr. Blaine's meaning, when he says to Mr. Lowell:

> You will be careful, in any conversations you may have, not to represent the position of the United States as the development of a new policy, or the inauguration of any advanced aggressive steps to be taken by this Government; it is nothing more than the pronounced adherence of the United States to principles long since enunciated by the highest authority of the Government, and now, in the judgment of the President, firmly inwoven as an integral and important part of our national policy.

If not diplomatic, this is certainly strange. In the view of common-sense, which is of course our only guide in interpreting the case, what Mr. Blaine says is not true; it is squarely contradicted by all the facts; and, as Lord Granville is presumably not a fool, it would be interesting to know what kind of a time Mr. Lowell had in carrying out his very curious instructions. The policy now advocated is emphatically a "new policy"—a policy that has taken shape only when there began to be some danger that the canal would be made; and it is not merely a change in our course of action, but it is an entire inversion of the historic policy of the Government. This nation has again and again explicitly proclaimed, and is now under solemn covenant, that it will not do exactly the thing it is now proposed to do. If the "new policy" is not in the teeth of an existing treaty, why are its advocates so frantic to have that treaty "torn up"—abrogated and got out of the way?

If it be said that our policy is that

of the old "Monroe doctrine," the reply is that this doctrine does not touch the case, and the action of the Government proves it. The doctrine was proclaimed by Mr. Monroe to prevent European powers from "oppressing" or "controlling" in any way the young American republics, and it has been construed only as against the attempts of those powers to found new colonies or make territorial acquisitions on this side of the Atlantic. That it was not held by the Government to exclude foreign participation in the construction and protection of such a work as the Isthmus Canal, is attested by the fact that in 1835, long after its promulgation, the Congress of the United States resolved, and four years later the Senate of the United States re-resolved, "that the President be requested to open negotiations with other nations" for the purpose of "ascertaining the practicability of effecting a communication between the Atlantic and Pacific Oceans by the construction of a ship-canal across the Isthmus, and of securing for ever, *by suitable treaty stipulations, the free and equal right of navigating such canal to all nations.*" This view was, moreover, embodied more than thirty years ago in a treaty of our Government with England, in which both parties agreed, with reference to any possible future ship communication across the Isthmus, that "*they will guarantee the neutrality thereof, so that the said canal may be for ever open and free*"; that "*vessels of the United States or Great Britain traversing the said canal, shall, in case of war between the contracting parties, be exempted from blockade detention or capture by either of the belligerents*"; and furthermore, "*that neither the one nor the other will obtain or maintain for itself any exclusive control over said ship-canal; agreeing that neither will ever erect or maintain any fortifications commanding the same or in the vicinity thereof.*"

Are we to understand, then, that there neither has been, nor is there intended to be, any departure from this deliberate, long-established, and honorable policy of the Government of the United States?

M. Delauney, a French *savant*, has been studying the problem of woman from an anthropological point of view to determine her intellectual status, which he maintains to be inferior to that of man. He intimates that "sentimental pretensions" being now made the basis of a political movement, it is necessary to deal with the subject scientifically. The investigation is of course a proper and an important one; but it has had a somewhat curious reception from the press—or those editors, perhaps, who suspect that the women may yet vote, and will remember things. These declare this article to be most horrible, but contrive, with a good deal of deprecation, to get as much of it before their readers as they seem to dare. We have had it translated for the benefit of such dauntless souls as are prepared to take their lives in their hands, and go through with it. Our own special trouble is, that in about six weeks we shall get a bushel, more or less, of answers to it, written very much alike, all in "hair-marks," and with very pale ink.

LITERARY NOTICES.

INTERNATIONAL SCIENTIFIC SERIES, NO. XXXVI.

Suicide: an Essay on Comparative Moral Statistics. By Henry Morselli, M. D., Professor of Psychological Medicine in Royal University, Turin; Physician-in-Chief to the Royal Asylum for the Insane. New York: D. Appleton & Co. Pp. 388. Price, $1.75.

Some two or three years since, the author of this book contributed quite an elaborate work in Italian to the "International Scientific Series." It at once took high rank as an authoritative presentation of the subject,

and was largely drawn upon by Continental and English periodicals in the discussions that followed its publication. Dr. Morselli has revised and abridged the original, expressly for the English version now issued in London and New York; and the work in its present form supplies a long-recognized want in our literature.

There are, however, those who will ask: "What has suicide to do with science? or, What place has such a work in the 'International Scientific Series'? People commit suicide," they will say, "because they are tired of life; it is a matter of morals; an act of volition originating in the will, which is free, and therefore not amenable to the methods of science."

To this, the simple reply is, that it is the office of science to investigate the regularities and the conditions, or, in other words, the laws of phenomena. The voluntary destruction of life is a social phenomenon, the investigation of which falls just as much within the scope of science as an inquiry into the conditions of combustion, the classification of minerals, or the laws of plant-growth. Dr. Morselli's book is a systematic and comprehensive inquiry into the phenomena, the conditions, and the laws of suicide. It is, therefore, a legitimate and important contribution to the science of sociology; and is, moreover, the most practical exemplification we have seen of the real significance of law in what are called the higher spheres of its application. In a notice like this we can only give a few illustrative results of his method.

In the first place, it has been found, by a long course of extensive and careful observation, as shown by statistics, which are simply numerical records of facts, that the phenomena of suicide occur with great regularity. The psychical laws, in fact, work with more uniformity than the physiological or organic laws. Suicides are more regular than births, deaths, and marriages; and it has also been established that it is on the increase in the most enlightened countries, so as to compel the conclusion that this result is due to advancing civilization. Dr. Morselli states this general result in the following form: "*In the aggregate of the civilized states of Europe and America, the frequency of suicide shows a growing and uniform increase, so that generally voluntary death since the beginning of the century has increased and goes on increasing more rapidly than the geometrical augmentation of the population and of the general mortality.*" Extensive tables are given, confirming this statement in a large number of countries.

But, though there is great regularity in the phenomena of suicide, this regularity is only under uniform conditions. Suicide varies as the conditions vary. Moreover, a large number of conditions are acting together, so that the result is a highly complex one. It is the work of the investigator to disentangle these conditions, so as to show the proper value of each. The general problem presents itself in this way. Suicide is a phenomenon occurring in all states of society. But in some countries its rate falls as low as twenty or thirty to a million inhabitants in a year, while in others it rises to perhaps one hundred and seventy to the million, and others show rates that are intermediate. In some cases, the figures from year to year are comparatively stationary, but fluctuate at different times of the year. In other instances, the annual figures fluctuate; and in all cases a variety of causes are at work to determine the result. The task of the statistician is to find out and express by numbers and averages the relation of the rates of suicide to these numerous accompanying conditions that are found to influence voluntary death. The task is an especially difficult one, but it has been accomplished with such success as to afford new and striking proof of the validity of sociological science. Dr. Morselli first considers the influence of the physical environment or the agencies of nature, as they affect the practice of self-destruction.

Men do not kill themselves in all climates alike. The influence of different regions is not great, but it is real. It has long been supposed that suicide is much more frequent in the north of Europe than in the south; and it has been found that it is more common in the northern than in the southern parts of France and Italy. But the old notion that Northern Europe is the "classic ground" of suicide is modified by later researches, which indicate that the excess is rather in the central region. Dr. Morselli says: "If of all the countries, dis-

tricts, provinces, and circles of Europe we form five groups, which we will call the North, West, Central, East, and South, we shall perceive the predominance of the central over the other four according to the method in which the countries indicated are placed in the scale of averages per million. In the center *two thirds* of the countries exceed the proportion of one hundred and fifty on the million; to the North about *three quarters* stand between fifty and one hundred and fifty, and in the South more than *three quarters* do not exceed the proportion of fifty suicides per million of inhabitants in the year."

But the influence of seasons over suicide is powerful. It varies greatly in different times of the year, and this variation is so regular that the number of those who will destroy themselves in the different months is predictable in each country. Many things about suicide are difficult to ascertain and more or less uncertain, but there is no doubt about the time of year; and it is entirely established that the maximum of suicide occurs in the hot season, and the minimum in the cold season. Fig. 1 is a copy of one of Morselli's diagrams showing the comparative monthly variation of suicide in five countries. By tracing each line representing a country, its height at each month indicates the proportion given in the left-hand column.

We can not say anything here of the influence of geology or of meteorology, or of the moon, or of the days of the month, or

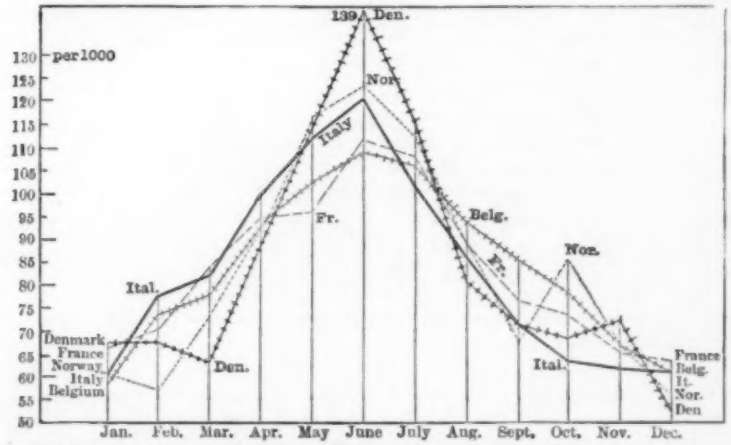

FIG. 1.—MONTHLY CURVE OF SUICIDE IN FRANCE, ITALY, NORWAY, BELGIUM, AND DENMARK. (Maximum in June.)

of the hours of day or night, by all of which the rates of suicide are shown to be affected.

Under the title "Ethnological Influences," Dr. Morselli treats of races, stocks, nationalities, anthropological characteristics, and customs. As regards ethnic influences it is shown that the Germanic race is most addicted to suicide, while the two stocks, German and Scandinavian, divide this supremacy; the Jews, on the other hand, stand lowest in the scale. There seems to be a relation between suicide and anthropological characters, of which the following example is given: "*The frequency of suicide in the various parts of Italy generally is in a direct ratio with stature, and the inclination to self-destruction increases from south to north as the stature of the Italians gradually increases.*"

The social environment, or social influences, affecting suicide are treated in a chapter of the work of great interest and instruction. The topics dealt with are the nature and effect of civilization; the influence of different forms of religious worship and creed; the effect of culture and instruction; the influence of public morality; general economical and political conditions; the density of population; and city and country life.

Chapter V is devoted to "The Influence

of Individual Conditions," such as sex, age, vocation, profession, and individual status in government and society. Here also, as in the former chapter, we are tempted to give results which space forbids. But in regard to sex it may be remarked that, so

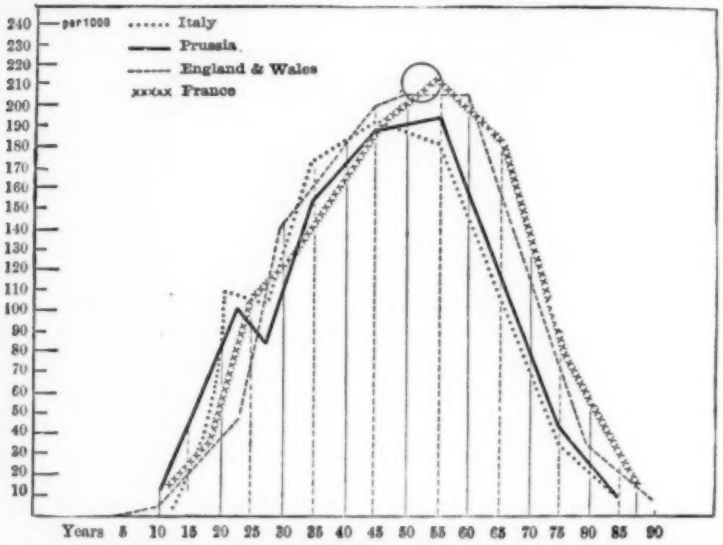

FIG. 2.—AGE OF SUICIDES IN ITALY, PRUSSIA, ENGLAND, AND FRANCE. (Curve of the returns per 1,000 of the actual numbers.)

profoundly different are the characteristics of the sexes, we might expect a great difference in their proneness to suicide, and such is the fact. But the result is different from what we should expect if we accept the statements of reformers, who tell us

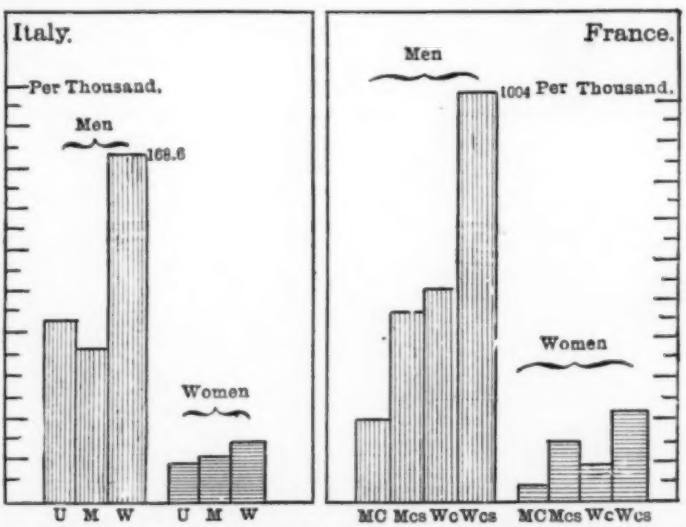

FIG. 3.—INFLUENCE OF THE CIVIL STATUS (ITALY) AND OF THE FAMILY (FRANCE) ON THE TENDENCY TO SUICIDE. *U* unmarried, *M* married, *W* widowed; *Mc* married with children, *Mcs* married childless, *Wc* widowed with children, *Wcs* widowed childless.

that women have hitherto been the sufferers from a systematic oppression which has made life a burden, while tyrannical men have made existence pleasant by abusing the weaker sex. Yet suicide is everywhere three or four times more frequent among men than among women. It is remarked that suicide is more frequent among Spanish women than those of any other country; and, curiously enough, that the proportion is generally found to decline with the greater preponderance of women in any country. Age also powerfully influences suicide, and nearly equally so in both sexes. The time of life most favorable to suicide is from twenty to fifty years of age; but the greatest proportion happens between forty and fifty. Dividing life into periods of ten years, it will be found that the fifth decennial period stands highest, and curves have been constructed to represent graphically to the eye the rate of increase and decline. Fig. 2 illustrates this for four countries.

Under the head of civil and social status, Dr. Morselli considers the influence of celibacy, marriage, widowhood, and the presence or absence of children. Those conditions are very different and marked in their effects. In Italy, France, and Switzerland, suicides are less numerous among single than among married women. In Italy, if the suicides among single women are represented at 90, those of married women will be 100, and of widows 147; and in France, if the probability of suicide among married men is represented by 100, that of single men will be 111·4, and of widowers, astonishing to say, 256. Fig. 3 brings out some of these results very strikingly.

There are many other points of interest in the volume which we can not even name. The discussion of the philosophy of the subject, its moral aspects, and under what condition the suicidal practice is to be diminished in future, is clear, sagacious, and instructive. The subject has always a mysterious fascination, but as here considered it has also a rational and scientific interest that will command the attention of all thinking people.

In a chapter on the modes and instruments of self-destruction, it is shown that even here there is a predictable regularity.

THE FOREIGNER IN CHINA. By L. N. WHEELER, D. D. With an Introduction by Professor W. C. Sawyer, Ph. D. Chicago: S. C. Griggs & Co. Pp. 268. Price, $1.25.

DR. WHEELER has here given us an extremely readable little volume, treating various aspects of matters in the "Flowery Kingdom." He was a Methodist missionary in China from 1865 until 1873. He preached to the natives in their own language, and devoted himself actively to missionary work through the preparation of many English and Chinese publications. His familiarity with the native written and spoken language gave him advantages in studying the character of that people, of which he seems to have well availed himself. There are more candor and fairness in his pages than might be expected of one, under the powerful bias of religious partisanship, who goes to a distant country for the avowed purpose of overturning its system of faith. His chapters on Chinese history, diplomatic intercourse, and on the origin and effect of the various wars—external and internal—in which the empire has been involved in modern times, are most interesting and instructive. As between the peaceable pagans, who are content to be let alone, and the aggressive Christian nations, who have been bent upon opening the Celestial Kingdom to the benefits of civilization, Dr. Wheeler does not fail to recognize that the heathen have much the better showing. After giving an account of the Chinese policy, and the wars and their results, in the first eight chapters, the author passes to the subject of the religious conversion of the Chinese people. An account of the Roman Catholic missions is followed by that of the Protestant missions, and a discussion of the hindrances to evangelism, after which he devotes a chapter to proving that Protestant missions are not a failure. He points out the great difficulties of the work, and gets a standard of what constitutes success in dealing with such a nation by showing that all other efforts to influence the Chinese—diplomatic, commercial, and military—have been anything but successful. Judged "by the same tests as we apply to more mundane undertakings," missionary work, he thinks, is not to be pronounced a failure. But Dr. Wheeler's ideas of success are certainly

large, if not peculiar. He says, "Were there not a single convert to Christianity in the Chinese Empire to-day, it would still be too early to pronounce unfavorably on missions." When we remember, as the author tells us, that the Christian gospel was introduced among the Chinese as early as A. D. 300; that Nestorian Christian missionaries began work there in A. D. 639; that the Catholic Church entered upon this missionary field more than six hundred years ago; and that the Protestant Church began its missionary labors there early in the present century—the statement that, if there were not a single convert to Christianity in the Chinese Empire to-day, it would still be too early to draw an unfavorable inference as to future prospects, shows that faith pays but very little regard to the inductions of experience. The doctor, moreover, interprets success in a very liberal way, considering it rather a problem of spiritual dynamics than of mere numbers. He says, "As each idolater was held fast by the entire force of native superstition, the conversion of one was a triumph over the whole might of paganism."

As to Confucianism, the religion of China, Dr. Wheeler has no hesitation in declaring that to be a "stupendous failure," leaving the people in a wretched spiritual condition, notwithstanding its long and undisturbed ascendency. He quotes the Rev. William Ashmore, who describes the prevalence of the precepts of Confucius as follows: "The roads to honor, to wealth, and to official preferment all start out from the skill displayed in stating and applying the maxim of the sage and his expounders. The most powerful social class is composed of those who have been covered with literary honors for their proficiency in the knowledge of Confucius. Confucianism is really the state constitution; it is the state religion; it is the state etiquette. Confucius and his teachings are worshiped by three hundred million people. The words that fell from his lips form the thesis of all the literary tournaments of the empire. They are graven deep on granite monuments. They are posted on the doorways of pavilions and rest-houses every year. They are written on fans that are ever in hand. They are painted on bed-curtains. They are gilded on rolls and hung up to adorn their temples and dwelling-houses. They furnish the phraseology with which men of polite learning exchange amenities with each other; and they may be heard falling from the lips of the common people in the markets when chaffering about the price of shrimps and snails."

And yet, notwithstanding all this, the moral condition of the Chinese is anything but satisfactory. The virtues of benevolence, integrity, propriety, wisdom, sincerity, with filial piety, are so far exemplified in the daily life of the people as to explain their remarkable longevity as a nation; their love of fixed and orderly modes of life; their thrifty habits; and their general tendency to practice the arts of peace. But the people are untruthful and dishonest, and, notwithstanding their ostentatious politeness, are coarse and brutal under the surface, and are loose, lewd, and polygamous.

Professor Sawyer's introduction to the volume is a brief essay on the present American aspects of the Chinese question. He considers it from the point of view of the recent treaties with China negotiated by the American envoys, Angel, Swift, and Prescott, the text of these treaties being given at the close of the volume. Professor Sawyer takes what may be called the liberal or anti-Californian view of the subject. He shows the futility of the reasons commonly offered for excluding the Chinese from the country, and in this connection remarks: "We have long endured the immigration of Celts and Teutons at a rate fifty times more rapid than the coming of the Celestials, and no political economist would dare to say that we should be better off without them, although they have made it almost impossible to govern New York and some other cities even respectably? Strange to say, these very Celts and Teutons are the men whose minds are most exercised lest we should be overrun by an inferior race; and their hoodlum sons, not the Chinese, are the disturbing element in San Francisco."

A HAND-BOOK OF VERTEBRATE DISSECTION. By H. NEWELL MARTIN, D. S. C., and WILLIAM A. MOELE, M. D. Part I. How to dissect a Chelonian. New York: Macmillan & Co. 1881. Pp. 94. Price, 75 cents.

THE multiplication of special monographs for guidance in practical scientific study is

an excellent sign of the times, as it becomes an index of activity in the field of experimental work. But these little manuals of practice are generally prepared with no other view than to serve as convenient helps in manipulation, and are but rarely steps in a broad, well-defined educational plan. The little book before us is of a different character, and has its place as part of a comprehensive system of biological study.

Professor Martin, who has charge of biology in Johns Hopkins University, has organized his department of teaching on a rational basis, and this book is the first installment of a series of small hand-books which has had its origin in his experience and necessities as a teacher. His theory of the method of study, which is hardly new, but has not been before reduced to a working system, is that students should first acquire some general idea of the elements and relations of their subject before concentrating study upon special divisions of it. In accordance with this idea, he some years ago, in connection with Professor Huxley, issued a volume called "Practical Biology," which was designed to introduce students to this science by observations of the structure and life-history of a number of typical plants and animals. It assumed that there is properly a science of living beings, as such, quite apart from any division of them into animals and plants. The course of study prescribed was experimental and thorough, and designed to lay a firm foundation for the further pursuit of the subject. Being thus grounded in general biology, the student is prepared to take up botany, or animal anatomy and physiology, and proceed with them to the greatest advantage. The present hand-book comes in at this point when it is proposed to enter upon the scientific investigation of vertebrates, and it shows him "how to dissect a chelonian." The *Chelonia* are reptiles of the tortoise kind, and among these Professor Martin selects the Red-bellied Slider Terrapin for dissection, and adapts his book to the details of its structure. But, if students can not find this species, Professor Martin says that it is quite as well, and even in some respects better, to obtain species slightly different from the one described; the attention of students being kept more alert when they find they can not altogether rely on the description in the book, but have to look at everything carefully for themselves.

The present monograph will shortly be followed by two others, containing directions for the dissection of a pigeon and a rat, both of which are nearly ready for publication. The series will ultimately include a bony and a cartilaginous fish, a lizard, and one of the large-tailed amphibia, and when completed the series will form a Hand-book of Vertebrate Dissection.

ALGEBRA FOR SCHOOLS AND COLLEGES. By SIMON NEWCOMB, Professor of Mathematics, U. S. Navy. New York: Henry Holt & Co. 1881. Pp. 454. Price, $1.90.

A CHARACTERISTIC of this book is that, for the convenience of teachers, it is divided into two parts: the first adapted to well-prepared beginners, and comprising about what is commonly required for admission to college; and the second designed for the more advanced general student.

In the preparation of his work, Professor Newcomb recognizes two important principles in education which are much overlooked, and are novelties in their application to algebra. The first is that, in the acquisition of knowledge, an idea can not be very fully grasped by the youthful mind unless it is presented under a concrete form. This requires that, whenever possible, an abstract idea should be embodied in some visible representation, and all general theorems presented in a variety of special forms. In accordance with this principle, numerical examples of nearly all algebraic operations and theorems have been given. Algebraic operations with pure numbers are made to precede the use of symbols, and the latter are introduced only after the pupil has had a certain amount of familiarity with the distinction between algebraic and numerical operations. The second principle is the importance of time in mental processes. All mathematical conceptions require time to become ingrafted upon the mind, and the greater their abstruseness the more time is needed. The author is of the opinion that the backward state of mathematical instruction in this country, as compared with Europe, is due to a neglect of

this principle. He says: "Let us take, for instance, the case of the student commencing the calculus. On the system which was so universal among us a few years ago, and which is still widely prevalent, he is confronted at the outset with the number of entirely new conceptions, such as those of variables, functions, increments, infinitesimals, and limits. In his first lesson he finds these all combined with a notation so entirely different from that to which he has been accustomed, that before the new ideas and forms of thought can take permanent root in his mind he is through with the subject, and all that he has learned is apt to vanish from his memory in a few months. To meet this difficulty, the author has not scrupled to deviate from strict logical order to introduce the more advanced conceptions, disguised, perhaps, under some simple form at the earliest practicable period in the course. Some familiarity with ideas is thus acquired before their more formal enunciation. The practical feature of the work subsidiary to this principle consists in subdividing each subject as minutely as possible, and exercising the pupil on the details preparatory to combining them into a whole. Exercises in the use of algebraic language have been made to precede any solution of problems. In general, each principle which is to be presented or used is stated singly, and the pupil is practiced upon it before proceeding to another."

These features of the work certainly conform to sound educational philosophy, and they justify the conclusion that it has been executed throughout in a similar spirit. Professor Newcomb's reputation as a mathematician will be sure to commend his work to the favorable regard of teachers, and experience with it will test the fidelity with which he has applied the principles we have referred to, and others of perhaps equal importance which we have not space to notice.

MAN'S ORIGIN AND DESTINY, SKETCHED FROM THE PLATFORM OF THE PHYSICAL SCIENCES. By G. P. LESLEY, State Geologist of Pennsylvania. Boston: George H. Ellis. Pp. 442.

THE chief portion of this volume was prepared as a series of lectures, and delivered at the Lowell Institute, Boston, in 1866. They were published in a volume under the present title in 1868, and, the work continuing to be called for, some slight corrections were made in the plates, and a new edition is now issued, to which six more lectures are added.

It was the author's aim in his lectures "to attempt to show how far the sciences, as they are now advanced, succeed in throwing light upon the early history of our race"; or "to stimulate one class of minds by certain new suggestions respecting the correlation of the physical sciences with the history of mankind." His book is in no sense the systematic exposition of a theory which he claims as his own, but is rather a free, discursive interpretation and criticism of some of the leading doctrines and tendencies of modern scientific thought. The purpose and quality of the work are sufficiently indicated in the following prefatory passage: "The author never contemplated anything beyond a general sketch of the present bearings of science upon the vexed question of the origin and early history of man. But the question has many subdivisions. He intended the several lectures to be separate sketches of those subdivisions of the field of discussion—mere introductions to their proper study. His views are stated, therefore, in round terms. Nothing is closely reasoned out. Much is left to the logical instinct, and more to the literary education, of the reader. Reference is everywhere made to the sources of information within easy reach of all. Even the style of an essay has been avoided. The book is merely a series of familiar conversations upon the current topics of interest in the scientific world."

We have gone through Mr. Lesley's book with interest and profit—pleased with its brilliant and forcible passages, which are frequent; instructed by its learning and its abounding facts, and stimulated by its incisive observations and its forcible arguments. But the work is strongly stamped with the author's individuality, and its supplementary chapters especially, fresh and breezy as they are, contain various opinions to which we find it impossible to subscribe. The view taken of sociology, in the lecture on "The Social Destiny of the Race," appears to us inadequate and not up to the times; and in the lecture on "The Future

Economics of Mankind" we seem to hear the voice of a Pennsylvania official rather than the scientific master of economical principles. But, notwithstanding its faults, the work is original, helpful, and invigorating, and those who are concerned to note the drifts of modern inquiry will be sure to find it serviceable.

THE MICROSCOPE AND ITS REVELATIONS. By WILLIAM B. CARPENTER, M. D., F. R. S. Sixth edition. Illustrated by Twenty-six Plates and Five Hundred Wood-Engravings. Philadelphia: P. Blakiston & Co. 1881. Pp. 882. Price, $5.50.

THE admirers of the veteran physiologist Dr. William B. Carpenter will be gratified to learn that his surrender of the registrarship of the University of London, to which he had given nearly a quarter of a century of his life, was not the signal of retirement from scientific labor. On the contrary, liberation in one field has only led to greater activity in another. His elaborate work on the microscope has long been a standard for practical students, and has well kept up with microscopical improvement and progress. In preparing the fifth edition the pressure of official duties upon his time made it necessary to call in assistance in getting ready certain parts of the work. But, being recently more at liberty, he has rewritten those parts, and has devoted himself to the task of thoroughly revising and much extending the whole treatise in this sixth edition. We have spoken of former editions of the book in terms of strong commendation, and an examination of the present has only served to heighten our estimate of its excellence. It is encyclopedic in scope, and profusely and elegantly illustrated. The ease and clearness of Dr. Carpenter's style are well known, and no book that he has written better illustrates these qualities than "The Microscope." There is another feature of the work that adds greatly to its popular value—the large amount of interesting information in each department of natural history, which is made a subject of microscopical study. While 266 pages are devoted strictly to the construction, forms, properties, and manipulation of the instrument, more than 600 pages are given to its applications in the living world. This greatly enhances the interest of the work, and gives it a completeness possessed by no other microscopical manual. Every one who has a microscope will need also Dr. Carpenter's book to get the most out of his instrument; and every one who has the book will be certain to want a microscope.

PUBLICATIONS RECEIVED.

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The New Botany. A Lecture on the Best Method of Teaching. By W. J. Beal, Ph. D., Professor of Botany in the Agricultural College, Lansing, Michigan. Pp. 15.

The New Ethics. An Essay on the Moral Law of Use. By Frank Sewall. New York: G. P. Putnam's Sons. 1881. Pp. 61. 75 cents.

Quarterly Report of the Chief of the Bureau of Statistics for the Three Months ended June 30, 1881. Washington: Government Printing-Office. Pp. 107.

Contributions to the Study of the Toxicology of Cardiac Depressants. I. Carbolic Acid. A Summary of Fifty-six Cases of Poisoning, with a Study of its Physiological Action. By Edward T. Reichert, M. D. Pp. 25.

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Tertiary Lake Basin of Florissant, Colorado. By Samuel H. Scudder. Washington. 1881. Pp. 22. With Map.

Ottawa Field Naturalists' Club. Transactions No. 2. Ottawa, Canada. 1881. Pp. 44.

On some Mammalia of the Lowest Miocene Beds of New Mexico. By E. D. Cope. 1881. Pp. 12.

On the Origin of the Iron-Ores of the Marquette District, Lake Superior, pp. 10; and On the Age of the Copper-bearing Rocks of Lake Superior, pp. 2. By M. E. Wadsworth. Cambridge, Massachusetts.

The Hessian Fly. Its Ravages, Habits, Enemies, and Means of preventing its Increase. By A. S. Packard, Jr., M. D. Washington: Government Printing-Office. 1880. Pp. 43.

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The Mother's Guide in the Management and Feeding of Infants. By John M. Keating, M. D. Philadelphia: H. C. Lea's Son & Co. 1881. Pp. 118. $1.

Florida, for Tourists, Invalids, and Settlers. By George M. Barbour. With Maps and Illustrations. New York: D. Appleton & Co. 1882. $1.50.

The Labor Question, or an Exact Science of Equivalents. Chicago: Legal News Co., Printers. 1881. Pp. 186.

Celestial Objects for Common Telescopes. By Rev. T. W. Webb, F. R. A. S. New York: Industrial Publication Co. 1881. Pp. 493.

First Annual Report of the United States Geological Survey. By Clarence King, Director. Washington: Government Printing-Office. 1880. Pp. 79. With Map.

Antiseptic Surgery. The Principles, Modes of Application, and Results of the Lister Dressing. By Dr. Just Lucas-Championnière. Translated and edited by F. H. Gerrish, M. D. Portland: Loring, Short & Harmon. 1881. Pp. 239. $2.25.

An Introduction to the Science of Comparative Mythology and Folk-Lore. By Rev. Sir George W. Cox, M. A. New York: Henry Holt & Co. 1881. Pp. 330. $1.75.

POPULAR MISCELLANY.

The Mammoth Cave.—Professor H. C. Hovey made some interesting statements at the last meeting of the American Association concerning recent discoveries, measurements, and temperature observations in the Mammoth Cave. No exact measurements of the cave have ever been given, and most of the statements that have been published rest upon the representations, seldom accurate, of guides and proprietors. Even after Professor Hovey had received permission to make his observations, he was requested by the manager of the cave not to make any of the facts he had gained public. This is for the fear that other land-owners near the cave may learn where to look to find a rival entrance to the one that is now known. A fairly correct survey was made about forty years ago, the results of which, after they had been purposely confused to some extent, were embodied in the map of "Stephen Bishop, the Guide," but the map gave too correct information to suit the jealous proprietors, and was destroyed. Only one copy of it is now known to exist. Dr. Forwood's map, published in 1870, was declared to contain several deviations from accuracy. Dr. Blackall, of Chicago, made a careful survey, several years ago, on the basis of which he prepared a lecture, but was prevented from delivering it by an injunction. Another survey was made by Jeffreys, but the person who had possession of the notes has died, and they can not be found. Mr. Klett, the manager of the cave, is making a thorough survey, the results of which, it is hoped, the proprietors may be induced to allow to be published. Professor Hovey is himself trying to collect all the descriptions of American caverns, and has accumulated quite a voluminous mass of cave literature, embracing more than a hundred distinct treatises of greater or less importance. The cave is stated in Owen's "Geological Report of Kentucky" to include two hundred and twenty-three avenues. Professor Hovey visited fifty-three avenues, and could get accounts of only eighty. A curious property was observed in Echo Hall, in that at a point about midway in the stream, when the notes of a full chord are sounded in slow succession, they are repeated by the arched wall overhead in *arpeggio*, and accompanied by a wonderful deep undertone. In regard to the question whether carnivorous animals accustomed to living in the open air would make their abode in caves, a dog, which had made repeated trips to the cave, finally staid at a point beyond Echo River, seemingly happy and contented, and refused to go out. The highest temperature of the cave in the hottest season does not exceed 56° Fahr. The lowest temperature was 33°. Professor Hovey spoke of the extensive saltpeter-works that were instituted at the cave during the War of 1812, whence immense quantities of the salt were carried to Philadelphia on mules and in ox-carts, the *débris* of which still exist in great heaps of lixiviated earth, but of which no adequate record has been made.

The Floating Gardens of Cashmere.—The floating gardens of the Lake of Serinagur, Cashmere, are among the most curious specimens of horticultural art. A group of them when viewed in the evening gives an effect much like that of a harbor with its fleet of ships rising and falling with the swell of the waves. The foundation of the garden is formed by planting long stakes in the lake in two or three rows, at distances

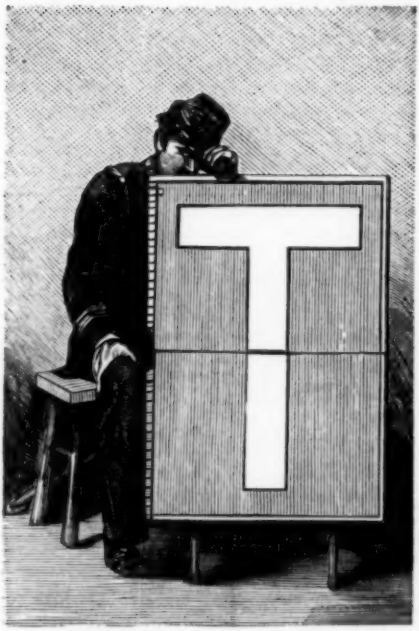
apart varying according to the size which it is intended to give the bed. Rooted plants are gathered from the lake and interwoven with the stakes. They continue to grow and form the floor of the bed, upon which more plants brought up from the lake are piled, until a kind of hill is formed half a yard in diameter and about two feet high. These hills are placed at distances apart which vary according to the nature of the vegetables that are to be raised upon them; the weeds of which they are formed soon dry up and decay, and the plants which are to be cultivated, consisting mostly of melons and allied species, are taken from the seed-beds in which they have been started, and planted upon them. At first, the plants are watered regularly, but their roots soon reach the water beneath the floor, and they then take care of themselves. The products of the gardens are gathered during the summer as they mature, by means of little boats which circulate among the floats, and are taken to the city and sold to a population which willingly pays a good price for them. The floating gardens will last for a great many years, or until the stakes which support them are rotted away, and may be perpetuated for an indefinite period by simply renewing the stakes at the proper time. They can be moved, but are generally fixed at the spot which the cultivator selects as most convenient for himself. Floating on the surface of the water, they rise and fall with the rise and fall of the lake, without any interruption to the development of the crops growing upon them. A very large amount of produce is raised upon the lake. Besides those plants which are cultivated directly, it furnishes several other useful productions spontaneously, such as the lotus, whose roots look like giant asparagus, without having its taste or flavor, but the seeds of which remind one of fresh nuts; water-chestnuts (*Trappa natans*), which are abundant; and quantities of water-lilies, the seeds and roots of which are often eaten. The fish also are excellent, varied, and abundant. The government derives a considerable revenue from the rent of fishing and gardening privileges.

Characteristics and Diversities of Deep-Sea Fauna.—M. A. Milne-Edwards has derived some novel and interesting if not startling conclusions from the study of the deep-sea fauna which were discovered by the dredging expeditions in the Caribbean Sea. He has been especially struck by the differences that exist between the animals of the bottom of the ocean and those of the surface and littoral. When, he says, we compare the specimens, we seem to have under our eyes two distinct fauna, which belong neither to the same period nor the same climate. The importance of this fact ought not to escape any one, and geologists should take it into account in determining the age of any formation. In reality, there are being formed to-day in the same seas deposits of which the contemporaneousness can not be put in doubt, but which contain the remains of beings entirely dissimilar. The animals in the deposits near the shores are related to the highest types of organization; those of the deep-sea-beds are of a more ancient character. Some among them exhibit incontestable affinities with fossils of the secondary epoch; others resemble the larval state of certain existing species. The infinite variety of zoölogical forms excites astonishment, and makes the application of existing classifications almost impossible. Transition types abound, with numerous intermediaries between groups, which we have hitherto been in the habit of considering as distinct. "Researches," continues M. Milne-Edwards, "on the animals of great depths have only been begun; and when we compare the limited extent over which dredgings have been made with the immense spaces that have never been penetrated, when we reflect on the many causes which still make the retreats of certain animals inaccessible to any means of investigation that we have, we become convinced that the results which have been obtained are only a small part of what the future has in reserve for us. We can not, then, insist too much on directing the attention of men of science of all countries to the usefulness of making their efforts coördinate, and of undertaking methodical explorations in the seas to which they have the most easy access. Our zoölogical tables still present so many gaps that it is impossible to comprehend the wholeness of the plan which has presided over the grouping

of beings. Paleontological discoveries on the one side, and those which submarine explorations promise us on the other, will gradually fill these voids, and will, perhaps, some day permit naturalists to grasp the relations which exist between animals."

Images of the American Stone Age.—Among all the relics of the stone age, said Mr. William McAdams, in his paper on the subject, read at the Cincinnati meeting of the American Association, none are of more interest to the student of ethnology than the sculptured forms of men and animals found on some of the stone objects taken from the mounds. These objects might be divided into four classes: 1. The mound-pipes, with a curved or crescent-shaped base forming the stem, the bowl of the pipe representing some animal. These pipes are not made of very hard stone, as has generally been supposed. They are quite small and delicate, many of them showing both taste and skill in manufacture. 2. A class consisting of much larger and somewhat exaggerated representations of men and animals, many of them having a crouching, sphinx-like form, strongly resembling the ancient forms from the Nile. Some of them have no perforation, but the majority of them have two funnel-shaped perforations, and were probably used as pipes on occasions of great ceremony. Some of these images, from mounds in Illinois, weighing ten or twenty pounds or more, are sculptured from hard stone, and are among the finest works of the stone age. 3. A class of singular mask-like figures, in which the human face alone is represented presumably of the natural size. The fourth class consists of representations of the human form which may have been real idols. One from Union County, Illinois, cut from quartzite, the most refractory material known, represents the body in a sitting posture, with the hands on the knees, has a face with features not those of a modern Indian, is smooth and highly polished, and is, perhaps, the finest piece of aboriginal sculpture that has been found in the United States. Mr. McAdams thought these objects were used in religious observances, and believed that the evidence showed that the mound-builders were fire-worshippers. Professor Putnam, who is one of the unbelievers in a distinct race of mound-builders, remarked that many of the supposed idols, pipes, etc., may have been toys for children.

The Telelogue.—The visibility of signals designed to be seen at a distance depends upon the contrast between the light given by the signals and that of the ground against which they are seen. The contrast has commonly been obtained in aërial telegraphy by exhibiting dark bodies against the light of the sky. To make this effective, it is necessary to raise the dark bodies to some height, and this involves the use of apparatus which must be more or less cumbrous. In the telelogue of Captain Gaumet, the difference in brilliancy required to give distinctness to the signal is gained by employing a silver surface designed upon a dark ground. A slight inclination of the apparatus is enough to cause the silver to shine very brightly, and in strong contrast with the dark ground, by the reflection of the diffused light which it receives from the sky. For signals, Captain Gaumet employs the letters of the alphabet and the numerals, remembering that we most readily recognize those forms with which we are familiar. The telelogue consists of two essential parts: the telegraph-album, or book of signals, and a telescope. The telegraph-album is a collection of forty leaves of coarse black cloth on which the silver signals, including the letters of the alphabet, the numerals, and a few conventional signals, are fixed. To secure economy of bulk while the letters shall be as large as possible, each signal occupies the reverse of one leaf and the front of the leaf behind it, as is shown in the figure, where the leaf that is turned down bears the lower part of the T on its back, and the upper part of the letter is exposed on the leaf behind it. Each leaf is marked with an index to enable the operator to find it quickly. The cover of the album is made of stiff leaves, which put together form a table or a rigid back, and one of which is furnished with feet, to which a third foot is added, constituting a tripod when the apparatus is used. The telescope should be strong and very clear. The dimensions, both of the album and telescope, will depend on the



distance at which the signals are to be seen. At present three sizes are used, corresponding with distances of two and a half, eight, and ten and a half miles. The medium size measures about twenty by thirty inches, and weighs, with the telescope, less than twenty pounds. If the apparatus is to be used at night, artificial illumination will be needed; a petroleum-lamp with a reflector, or, for greater distances, two lamps, will be enough. To use the apparatus, the album must be fixed on its tripod at such an angle that the reflection from the silver shall be brightest, and shall reach the spot with which communication is to be had. A plate which is all silvered, and which appears in the distance as a bright point, is exposed as a signal of warning: the operator at the other post answers with an identical signal that he is ready. The letters composing the telegram are then exhibited one after the other, and the words are separated by showing the wholly silvered plate or plain spot. If any signal is to be repeated, as in the case of double letters or the repetition of a figure, it is hid for a moment by a black leaf and shown again. The operator at the other station receives the dispatch with the aid of his telescope, distinguishing the letters and spelling the words as they come, and writing them, or having them written, down. The image produced by these large characters, seen at a distance through the glass, corresponds with sufficient exactness with that produced by the same characters when read in a book or a newspaper. In the experiments that have been made, dispatches of twenty words have been transmitted in five minutes. Speed may be gained by using single conventional characters for the more common words. Secrecy may be secured by so fencing in the album as to prevent the diffusion of its reflection, and limit the field of its visibility to the other station, or by employing a cipher.

Ancient Aboriginal Houses.—Judge Henderson, of Illinois, discussing the character of the houses of the ancient inhabitants of the Mississippi Valley, said that it was a mistake to regard the "cone-like cabin"—which is really only a temporary hunting-hut or abode of a tribe in a nomadic condition—as the typical wigwams of the aborigines at the beginning of the historic period. Such houses were not found in the villages of the sedentary tribes, but these lived in large houses, each accommodating a number of families belonging to the same *gens*. These long houses were made with framework, and covered with such material as the country afforded—bark in the East, mats made from the leaves of the cat-tail in the prairies of the West—and were divided into sections by skins, sheets of bark, or mats hung up at intervals, and had a hallway in the middle, extending the full length of the house. One family occupied each of these sections, and a fire built in the doorway of every second partition served for two families. In the South, the houses were of sticks plastered with mud, and sometimes covered with mats, while the roof was covered with mats or thatched with straw or canes. The absence of any traces of ruins or of foundations shows that the houses of the ancient inhabitants of the land could not have been of stone, or massive structures of wood; and they could not have been of adobe, for that would not have withstood our winters. Professor Morgan's theory that the houses were pueblos, built

on raised terraces, like those found in the Ohio Valley, is not sustained, for no such terraces are found near the animal-shaped mounds of Wisconsin or the burial-mounds of the Illinois River. Judge Henderson believes, therefore, that the ancient houses were of a similar character to those that he has described as existing at the beginning of the historical period.

NOTES.

DENISON'S Improved Reference Index is an ingenious arrangement to give aid in making references in dictionaries and cyclopædias. It can be added to any such book at small cost and without disfiguring it, saves time and avoids perplexity at exactly the right moment when a reference is to be made. Instead of fumbling till patience is exhausted, and the mind distracted by the host of suggestions in looking over the pages—with the imminent danger of forgetting what one is after—Mr. Denison's device takes you to the letter you want instantly, by a single glance and a single motion. The invention is a godsend to students.

JOHANN MARIA HILDEBRANDT, a German African traveler of growing reputation, died in Antananarivo, Madagascar, while engaged in exploring the island, May 29th. Previous to going to Madagascar, he had spent several years on the eastern coast of Africa, and had had the honor of having a characteristic African moss (Hildebrandtiella) named after him. One of his later contributions to the Berlin Geographical Society's "Zeitschrift" contained an interesting description of the vernal phenomena in Madagascar, in which he said that spring arrives about the middle of November, when the cold southeastern wind which has blown throughout the winter, leaving its moisture on the eastern slopes of the forest-covered highlands and driving before it the savanna-fires, gives place to the northwestern wind, bringing warmth and moisture.

M. DE LESSEPS has been elected President of the French Geographical Society, "in recognition of the services he has rendered to science, and of his rank among the most illustrious men of his country and of the whole world." The enthusiasm which Frenchmen feel for their great engineer was tersely expressed by General Turr, who, asking the patronage of M. de Lesseps for his canal across the Isthmus of Corinth, styled him "General-in-Chief of Isthmuses and Canals."

JOHN DUNCAN, the weaver-botanist of Alford, England, died in that place, on the 9th of August, in the eighty-seventh year of his age. Though he had been known in private to a few men of science as a man dependent on daily labor for the means of subsistence, who had become perfectly accomplished in the botany of his district, and had made valuable researches in it, he was not known to the public till about a year ago. Then, when, enfeebled by age, he was about to fall upon the parish, Mr. Jolly, inspector of schools, published an account of his work and his condition in the newspapers. A general interest was awakened in his case, and subscriptions were spontaneously offered, which enabled him to pass his few remaining days in comfortable ease. What he had—his books and the proceeds of the subscriptions—he has left in trust for the promotion of the study of science in Alford and its neighborhood.

MR. HEWETT COTTRELL WATSON, one of the most indefatigable workers in British botany, died July 27th, in his seventy-eighth year. He was a prolific writer on the geographical distribution of British plants, and on the distinguishing characters of the more critical species, a contributor to periodicals, and editor of the "New Botanist's Guide," "Cybele Britannica," and the "London Catalogue of British Plants." In his garden were collected growing specimens of rare or little known British plants. He visited the Azores in 1847, with the result of adding much to the world's knowledge of the botany of the islands.

IT was already known that music exercises a very perceptible influence upon the circulation and respiration of the human subject. Recent researches by M. Dogiel have shown that the same is the case with animals.

DR. FERDINAND KELLER, the discoverer for science of the lake viliages of Switzerland, died at Zurich, May 19th, at the age of eighty-one years. His attention was first called to the lake villages in the winter of 1853–'54, when the remains of the structures at Obermeilen were made visible by an unprecedentedly low stage of the water in the Lake of Zurich. He communicated an account of what he had found to the Antiquarian Society of Zurich, and thereby awakened a lively interest in what has become one of the most engaging and instructive departments of prehistoric research.

M. DUBRUNFAUT, a French chemist of considerable merit, who has recently died at the age of eighty-four years, was best known by his discoveries of new processes in the manufacture of beet-sugar, which are still in use. At the time of his death he was engaged upon a treatise on human longevity.